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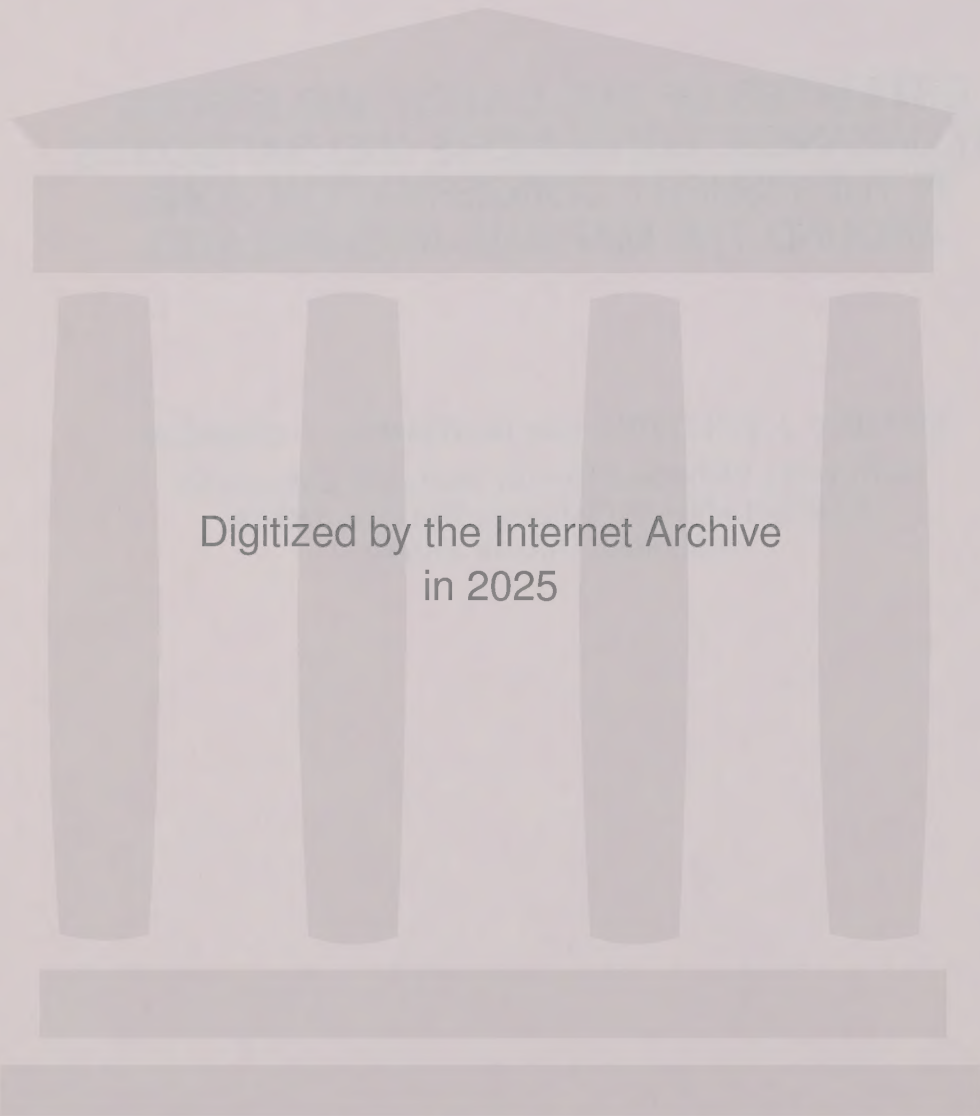


# ESTIMATES OF THE CATCH AND EFFORT BY JAPANESE LONGLINERS AND BAITBOATS IN THE FISHERY CONSERVATION ZONE AROUND THE MARIANA ARCHIPELAGO

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Tunas currently represent the most valuable marine resource found within the 200-mile Fishery Conservation Zone (FCZ) around the Mariana Archipelago. This report presents historical Japanese tuna catch and effort data and an analysis of the magnitude, species composition, and general location of the Japanese catches. Although there may be vessels from other nations fishing for tunas in the FCZ around the Mariana Archipelago, the vast majority of the effort and catch is thought to be due to Japanese vessels.

#### DATA SOURCES

This report is based on the same data sources used by Yong and Wetherall (1980); however, since their report was prepared 2 more years of data have become available and are incorporated into this report.

Two available data sets of Japanese longline catch and effort data for the western Pacific differ by their degree of data aggregation. One data set is the published Japanese longline catch and effort by month reported by 5° squares. This data set is available from 1965 to 1979. The second data set is Japanese longline catch and effort by month reported by 1° squares. These data are available from 1971 to 1979; however, for the period 1971-75 the data are reported only for the FCZ around the Mariana Archipelago south of lat. 20° N. These data were made available to the Southwest Fisheries Center, National Marine Fisheries Service by the Fisheries Agency of Japan. These data represent only a sample of the Japanese vessels fishing in the FCZ, so the data were adjusted or raised by applying raising factors taken from the "Annual report of effort and catch statistics by area on Japanese tuna longline fishery" published by the Fisheries Agency of Japan.

The catch data for both longline data sets are in numbers of fish caught. The numbers caught were converted to weight caught by using the mean weights in Table 1. The effort for the longline data sets is in vessel days.

The Japanese baitboat data are from published annual reports of the Fisheries Agency of Japan and are given as catch in metric tons and nominal effort in vessel days for 1° squares and 10-day intervals. Yong and Wetherall (1980) report that on the average the baitboat statistics cover about 80% of the actual catch, so we raised the catch and effort data by a factor of 1.25.

Table 1.--Estimated average weights (kg) used in computing longline catches in the Fishery Conservation Zone around Guam and the Commonwealth of the Northern Mariana Islands. (From Yong and Wetherall 1980.)

| Year           | Albacore | Yellowfin<br>tuna | Bigeye<br>tuna | Bluefin<br>tuna | Skipjack<br>tuna | Blue<br>marlin | Black<br>marlin | Striped<br>marlin | Swordfish | Sailfish and<br>spearfish |
|----------------|----------|-------------------|----------------|-----------------|------------------|----------------|-----------------|-------------------|-----------|---------------------------|
| 1975           | 25       | 28                | 38             | 237             | 5                | 55             | 79              | 34                | 30        | 22                        |
| 1976           | 24       | 30                | 39             | 237             | 5                | 55             | 79              | 34                | 30        | 22                        |
| 1977           | 24       | 30                | 37             | 237             | 5                | 55             | 79              | 28                | 30        | 22                        |
| Other<br>years | 24       | 29                | 38             | 237             | 5                | 55             | 79              | 32                | 30        | 22                        |



Figure 1 shows the boundary used for computing the catch and effort within the 50- and 200-mile FCZ of the Mariana Archipelago. Estimates of catch and effort within these zones were obtained by summing the catch and effort data for 1° and 5° squares within these zones. Where the 1° or 5° squares overlapped a boundary, it was assumed that the catch and effort were homogeneously distributed within the square and the fraction of the catch and effort of the total square within the bounded areas was assumed to be proportional to the relative area of the squares within the boundary.

#### JAPANESE LONGLINE DATA

The annual Japanese longline catch and effort data around Guam and the Commonwealth of the Northern Mariana Islands (CNMI) for the period 1965-79 are presented in Tables 2-16. The total tuna catches from Japanese longliners for the FCZ around Guam range from 9 to 1,334 metric tons (mt), and the catches for the FCZ around CNMI range from 71 to 576 mt. On the average about 80% of the tuna catch in the FCZ comes from outside the 50-mile zone. The billfish catch typically averaged about 30% of the total tuna catch, but since 1976 the billfish catches were only about 10% of the total tuna catches. The annual total tuna catch, effort, and catch per unit effort (CPUE) are summarized in Table 17 and the total tuna catch in the FCZ is plotted in Figure 2. It is interesting to note that over the period 1965-79, 1976-79 represents a period of above average CPUE and above average total tuna catches for Guam and CNMI. The Japanese longline catch for the principal species, albacore, Thunnus alalunga, yellowfin tuna, T. albacares, and bigeye tuna, T. obesus, are presented in Table 18 and Figure 3. During the period 1976-79 the increase in CPUE and total catch appears to be due to an increase specifically in catches of yellowfin and bigeye tunas.

Since the Mariana Archipelago is oriented on a north-south axis, catch and effort data by latitude indicates where along the chain the longliners are fishing. The total annual catch, effort, and CPUE data for tunas from Japanese longliners were summarized for the period 1971-79 where 1° square data were available (Table 19). These data show a general trend of increasing catch and effort in the lower latitudes from 11° to 16° N, and it is this area that contributed to the relatively high catch and CPUE for the period 1976-79.

The effort by month from Tables 2 to 16 suggests that prior to 1976 most of the effort was expended at the beginning or end of the year whereas after 1975 there was an increase in effort for the summer months. The monthly total tuna catch for two periods, 1971-75 and 1976-79, confirms that there was an increase in tuna catches during the summer months of 1976-79 (Table 20, Figures 4 and 5).

#### JAPANESE BAITBOAT DATA

The estimated annual catch and effort by Japanese baitboats in the FCZ around Guam and CNMI for 1970-79 are presented in Tables 21-30. Over 90% of the catch by weight is skipjack tuna, Katsuwonus pelamis, the remainder is composed mostly of yellowfin and bigeye tunas. The total tuna catch, effort, and CPUE are summarized in Table 31, and the total catch within the



FCZ for Guam and CNMI is plotted in Figure 6. The total tuna catch in the FCZ around Guam ranged from 83 to 2,059 mt and the catch in the FCZ around CNMI ranged from 2,554 to 12,564 mt. The highest catch in the FCZ around Guam for baitboats was made in 1977, the same year the longliners had their best catch around Guam for the period 1965-79. The total annual catch, effort, and CPUE data for tunas from Japanese baitboats in 1970-79 are presented by latitude in Table 32. Unlike the longliners there does not appear to be any movement in effort over latitude for this period, and good catches were consistently made in the middle latitudes between 16° and 21° N. The monthly pattern for catch, effort, and CPUE is fairly consistent over the period 1970-79 (Table 33). The catch, effort, and CPUE for baitboats in the FCZ around CNMI increase in the beginning of the year, reach a peak in July, and then decline at the end of the year. The pattern in the FCZ around Guam is not as clear but the catch, effort, and CPUE appear to peak earlier in the year around March or April (Figure 7).

#### LITERATURE CITED

Yong, M. Y. Y., and J. A. Wetherall.

1980. Estimates of the catch and effort by foreign tuna longliners and baitboats in the Fishery Conservation Zone of the central and western Pacific, 1965-77. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-2, 103 p.





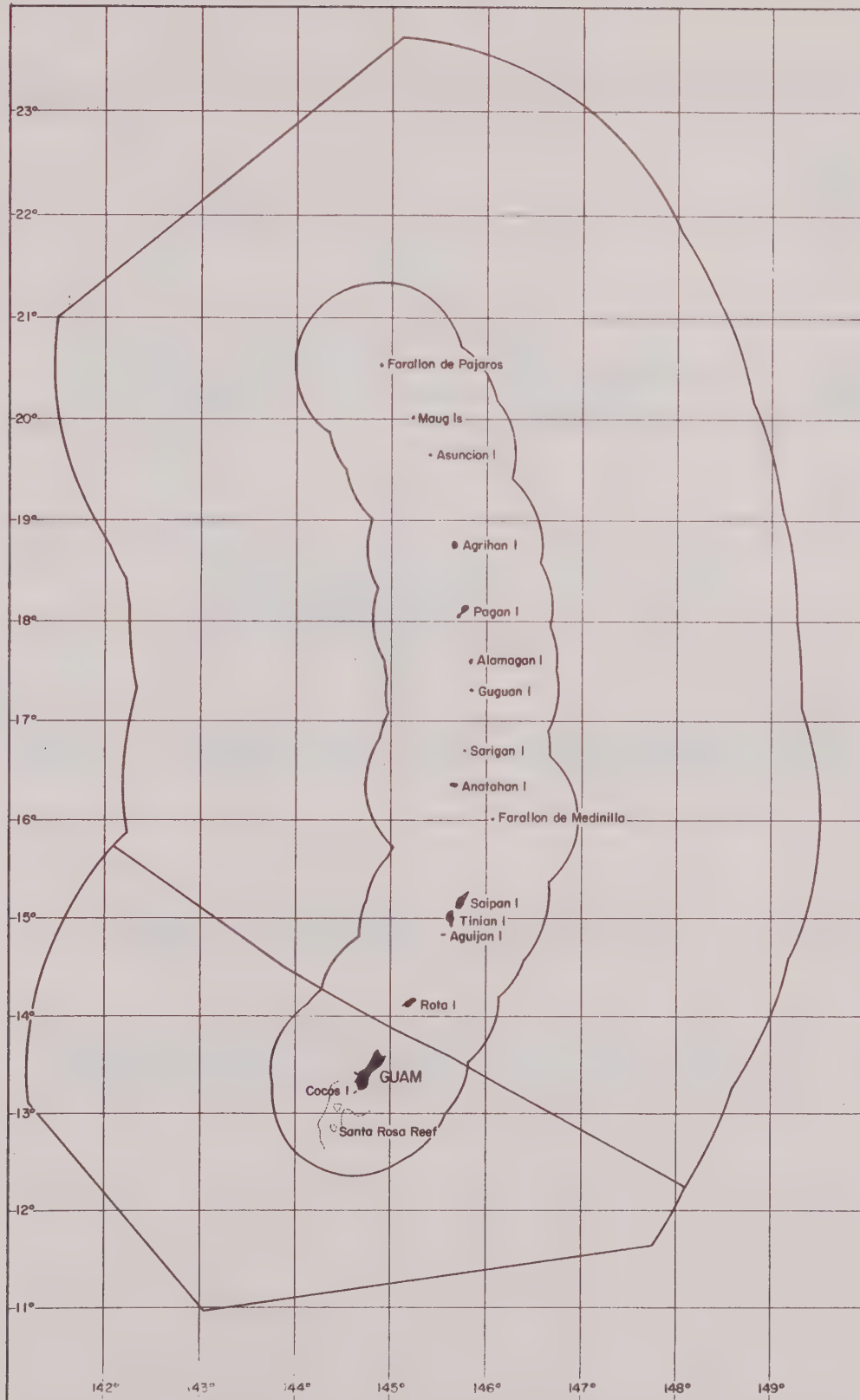


Figure 1.--The 50-mile limits and the Fishery Conservation Zone around Guam and the Commonwealth of the Northern Mariana Islands.

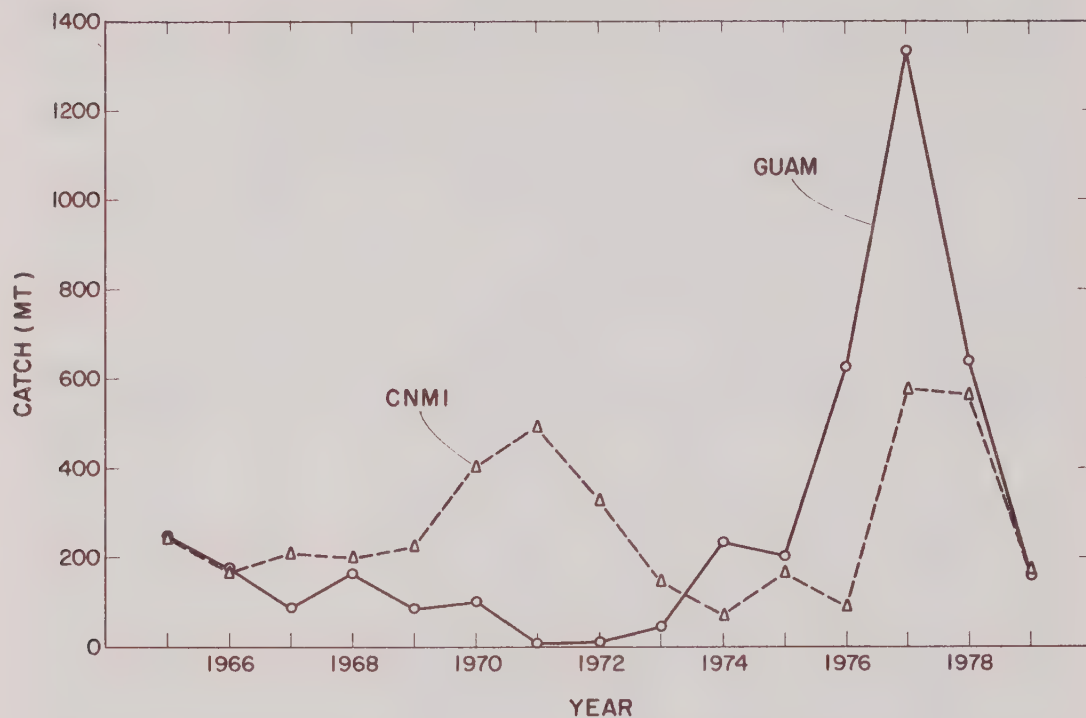


Figure 2.--Total tuna catches from Japanese longliners in the Fishery Conservation Zone around Guam and the Commonwealth of the Northern Mariana Islands (1965-79).



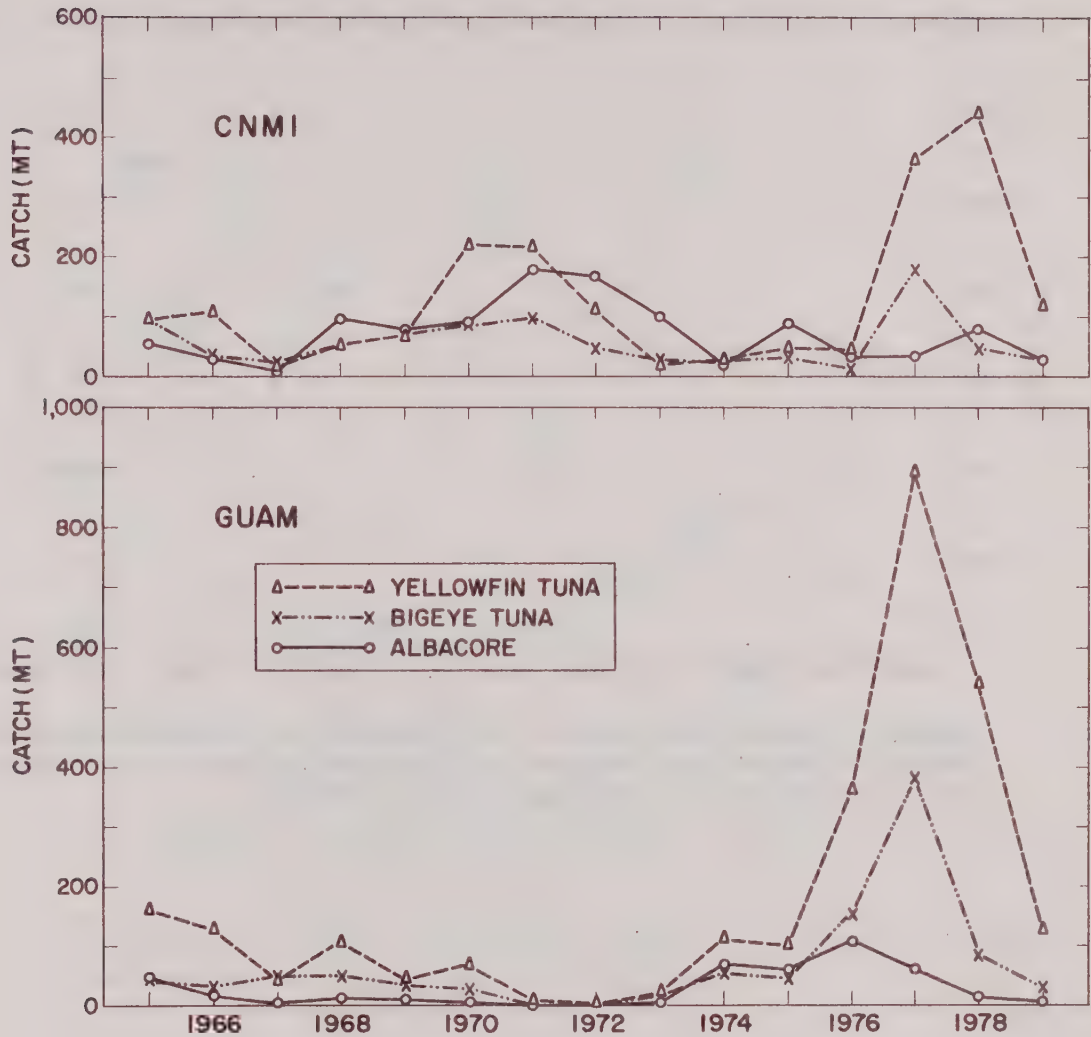


Figure 3.--Catches of albacore and yellowfin and bigeye tunas from Japanese longliners in the Fishery Conservation Zone around Guam and the Commonwealth of the Northern Mariana Islands (1965-79).

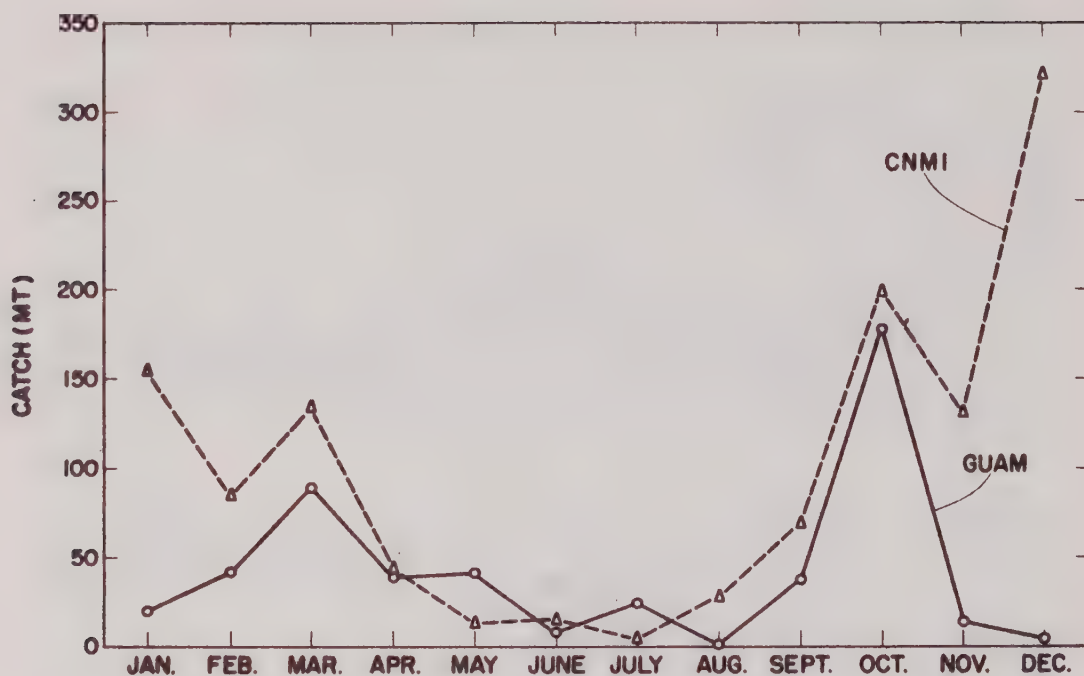


Figure 4.--Total tuna catches from Japanese longliners aggregated by month for the Fishery Conservation Zone around Guam and the Commonwealth of the Northern Mariana Islands (1971-75).



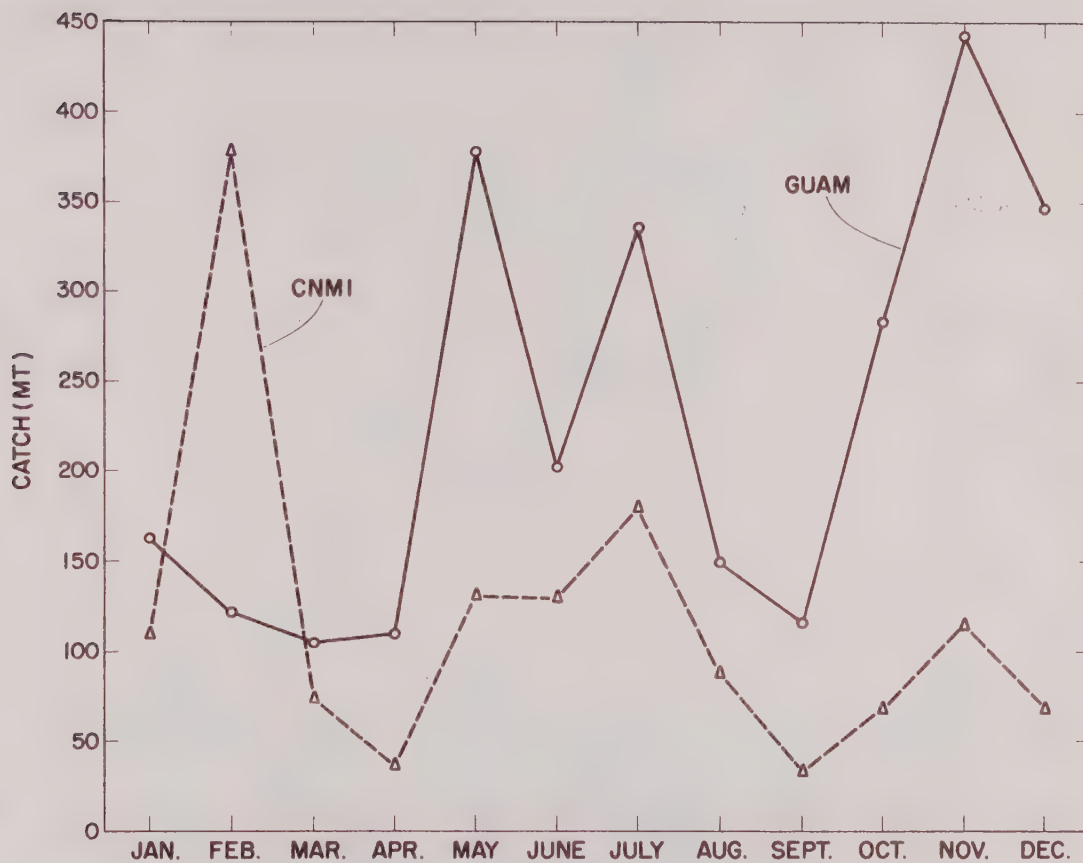


Figure 5.--Total tuna catches from Japanese longliners aggregated by month for the Fishery Conservation Zone around Guam and the Commonwealth of the Northern Mariana Islands (1976-79).

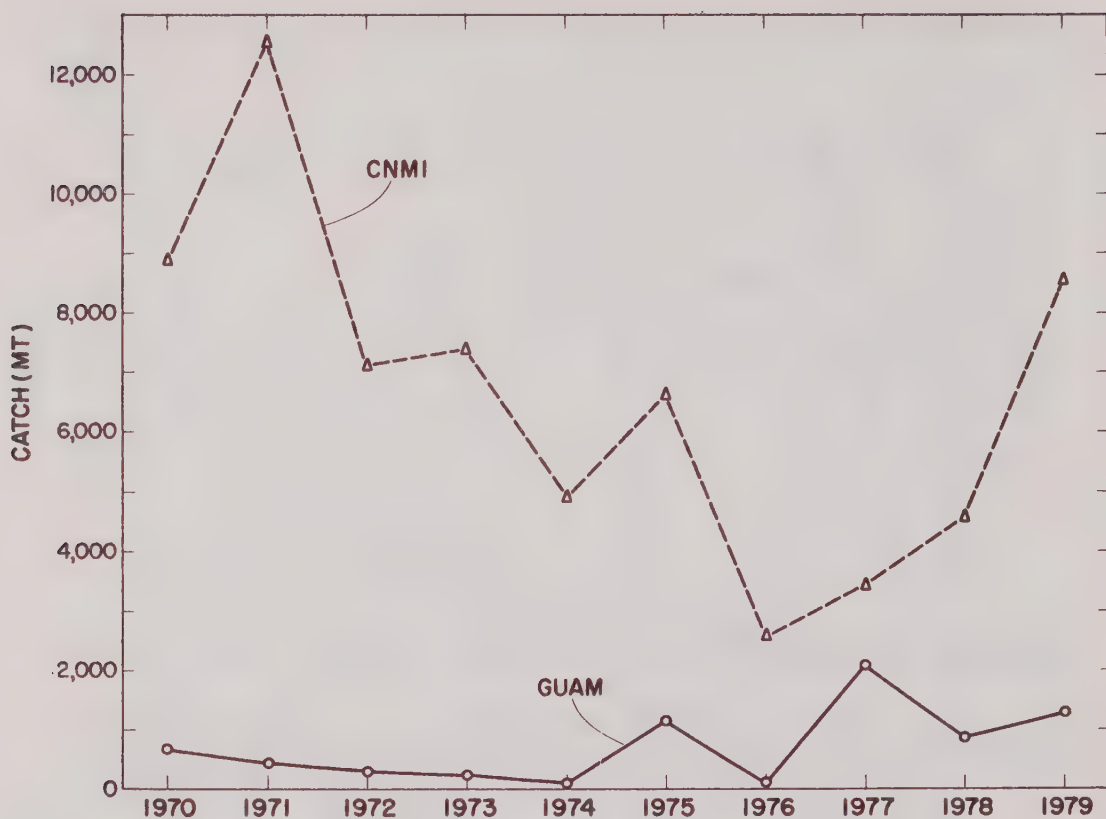


Figure 6.--Total tuna catches from Japanese baitboats for the Fishery Conservation Zone around Guam and the Commonwealth of the Northern Mariana Islands (1970-79).

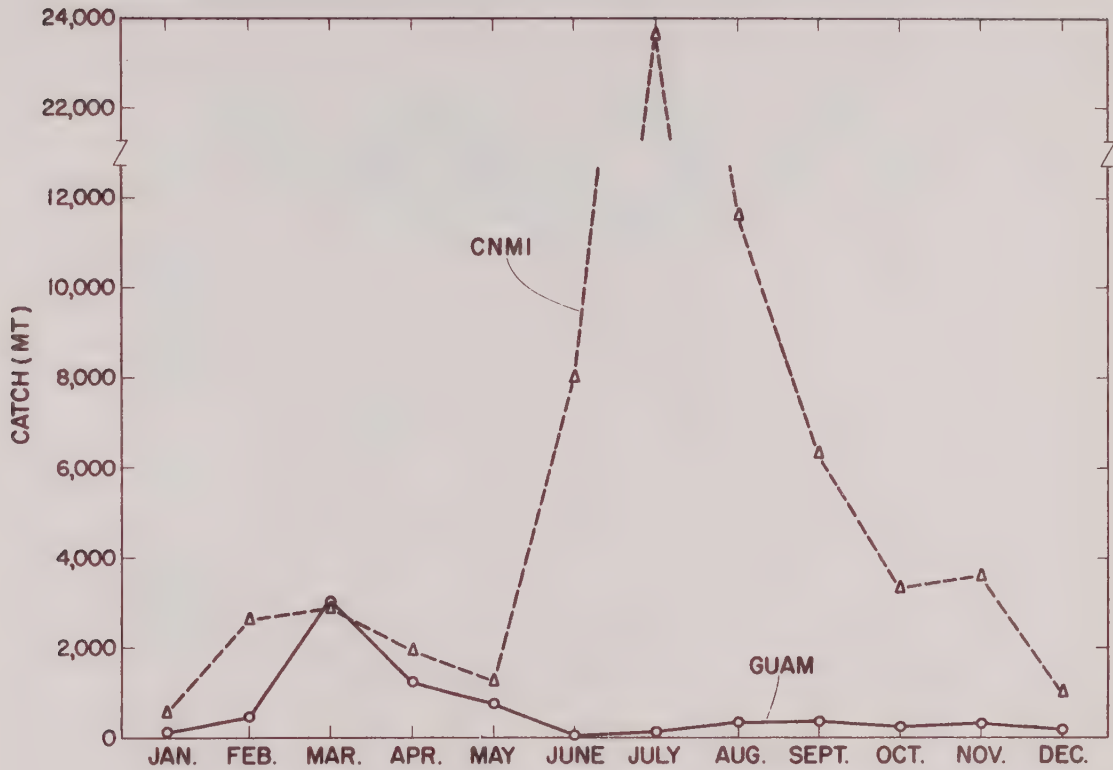


Figure 7.--Total tuna catches from Japanese baitboats aggregated by month for the Fishery Conservation Zone around Guam and the Commonwealth of the Northern Mariana Islands (1970-79).





Table 2.—Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1965. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 2             | 13         | 19            | 155        | 21                     | 168        |
| February                            | 3             | 17         | 11            | 87         | 14                     | 104        |
| March                               | 5             | 32         | 17            | 122        | 22                     | 154        |
| April                               | 1             | 4          | 3             | 27         | 4                      | 31         |
| May                                 | *             | 1          | 6             | 49         | 6                      | 50         |
| June                                | 1             | 4          | 6             | 41         | 7                      | 45         |
| July                                | 1             | 8          | 1             | 5          | 2                      | 13         |
| August                              | 1             | 7          | 1             | 4          | 2                      | 11         |
| September                           | 1             | 9          | *             | 1          | 1                      | 10         |
| October                             | 17            | 103        | 10            | 37         | 27                     | 140        |
| November                            | 4             | 27         | 4             | 20         | 8                      | 47         |
| December                            | 8             | 50         | 10            | 55         | 18                     | 105        |
| Total                               | 44            | 275        | 88            | 603        | 132                    | 878        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 8             | 48         | 8             | 55         | 16                     | 103        |
| Yellowfin tuna                      | 26            | 160        | 20            | 95         | 46                     | 255        |
| Bigeye tuna                         | 6             | 41         | 15            | 96         | 21                     | 137        |
| Bluefin tuna                        | *             | *          | *             | 2          | *                      | 2          |
| Skipjack tuna                       | *             | *          | *             | *          | *                      | *          |
| Total tunas                         | 40            | 249        | 43            | 248        | 83                     | 497        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 6             | 36         | 8             | 40         | 14                     | 76         |
| Striped marlin                      | *             | 1          | 4             | 36         | 4                      | 37         |
| Swordfish                           | *             | 1          | 3             | 24         | 3                      | 25         |
| Black marlin                        | *             | 1          | *             | 1          | *                      | 2          |
| Spearfish & sailfish                | *             | 2          | 1             | 7          | 1                      | 9          |
| Total billfishes                    | 6             | 41         | 16            | 108        | 22                     | 149        |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 3.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1966. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 1             | 6          | 4             | 33         | 5                      | 39         |
| February                            | *             | 2          | 4             | 30         | 4                      | 32         |
| March                               | 3             | 22         | 5             | 17         | 8                      | 39         |
| April                               | 6             | 36         | 6             | 37         | 12                     | 73         |
| May                                 | 3             | 22         | 6             | 43         | 9                      | 65         |
| June                                | 0             | 1          | 4             | 42         | 4                      | 43         |
| July                                | *             | 3          | 3             | 18         | 3                      | 21         |
| August                              | 3             | 18         | 5             | 24         | 8                      | 42         |
| September                           | 4             | 26         | 5             | 25         | 9                      | 51         |
| October                             | 9             | 55         | 5             | 19         | 14                     | 74         |
| November                            | 3             | 20         | 1             | 5          | 4                      | 25         |
| December                            | 2             | 15         | 3             | 16         | 5                      | 31         |
| Total                               | 34            | 226        | 51            | 309        | 85                     | 535        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 3             | 17         | 4             | 28         | 7                      | 45         |
| Yellowfin tuna                      | 20            | 126        | 19            | 106        | 39                     | 232        |
| Bigeye tuna                         | 5             | 31         | 6             | 34         | 11                     | 65         |
| Bluefin tuna                        | *             | *          | *             | 1          | *                      | 1          |
| Skipjack tuna                       | *             | *          | *             | *          | *                      | *          |
| Total tunas                         | 28            | 174        | 29            | 169        | 57                     | 343        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 4             | 29         | 6             | 39         | 10                     | 68         |
| Striped marlin                      | *             | *          | 1             | 9          | 1                      | 9          |
| Swordfish                           | *             | *          | 2             | 19         | 2                      | 19         |
| Black marlin                        | *             | 1          | *             | 1          | *                      | 2          |
| Spearfish & sailfish                | *             | 3          | 1             | 5          | 1                      | 6          |
| Total billfishes                    | 4             | 33         | 10            | 73         | 14                     | 106        |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.



Table 4.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1967. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 2             | 15         | 11            | 86         | 13                     | 101        |
| February                            | 7             | 44         | 13            | 80         | 20                     | 124        |
| March                               | 3             | 19         | 5             | 31         | 8                      | 50         |
| April                               | 4             | 26         | 10            | 46         | 14                     | 72         |
| May                                 | 5             | 28         | 7             | 42         | 12                     | 70         |
| June                                | *             | 3          | 8             | 65         | 8                      | 68         |
| July                                | *             | 3          | 1             | 4          | 1                      | 7          |
| August                              | 1             | 7          | 2             | 9          | 3                      | 16         |
| September                           | *             | 2          | *             | 1          | *                      | 3          |
| October                             | *             | 3          | *             | *          | *                      | 3          |
| November                            | 0             | 0          | *             | 2          | *                      | 2          |
| December                            | 3             | 16         | 12            | 102        | 15                     | 118        |
| Total                               | 25            | 166        | 69            | 468        | 94                     | 634        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | *             | 3          | 9             | 79         | 9                      | 82         |
| Yellowfin tuna                      | 7             | 42         | 9             | 47         | 16                     | 89         |
| Bigeye tuna                         | 7             | 44         | 13            | 81         | 20                     | 125        |
| Bluefin tuna                        | 0             | 0          | *             | *          | *                      | *          |
| Skipjack tuna                       | *             | *          | *             | *          | *                      | *          |
| Total tunas                         | 14            | 89         | 31            | 207        | 45                     | 296        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 3             | 17         | 5             | 27         | 8                      | 44         |
| Striped marlin                      | *             | 1          | 2             | 17         | 2                      | 18         |
| Swordfish                           | *             | 1          | 4             | 26         | 4                      | 27         |
| Black marlin                        | *             | 1          | *             | 1          | *                      | 2          |
| Spearfish & sailfish                | *             | 2          | 1             | 5          | 1                      | 7          |
| Total billfishes                    | 3             | 22         | 12            | 76         | 15                     | 98         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 5.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1968. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | *             | 3          | 8             | 64         | 8                      | 67         |
| February                            | 6             | 37         | 11            | 66         | 17                     | 103        |
| March                               | 12            | 74         | 14            | 84         | 26                     | 158        |
| April                               | 3             | 20         | 9             | 67         | 12                     | 87         |
| May                                 | 2             | 12         | 3             | 14         | 5                      | 26         |
| June                                | 2             | 14         | 4             | 33         | 6                      | 47         |
| July                                | 1             | 10         | 6             | 51         | 7                      | 61         |
| August                              | 2             | 15         | 1             | 4          | 3                      | 19         |
| September                           | 2             | 10         | 1             | 6          | 3                      | 16         |
| October                             | *             | 3          | 1             | 3          | 1                      | 6          |
| November                            | 1             | 6          | 1             | 10         | 2                      | 16         |
| December                            | 2             | 10         | 10            | 83         | 12                     | 93         |
| Total                               | 33            | 214        | 69            | 485        | 102                    | 699        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 2             | 12         | 10            | 95         | 12                     | 107        |
| Yellowfin tuna                      | 17            | 104        | 11            | 52         | 28                     | 156        |
| Bigeye tuna                         | 8             | 48         | 9             | 52         | 17                     | 100        |
| Bluefin tuna                        | *             | *          | *             | *          | *                      | *          |
| Skipjack tuna                       | *             | 1          | *             | *          | *                      | 1          |
| Total tunas                         | 27            | 165        | 30            | 199        | 57                     | 364        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 3             | 20         | 4             | 25         | 7                      | 45         |
| Striped marlin                      | *             | 1          | 2             | 16         | 2                      | 17         |
| Swordfish                           | *             | 1          | 4             | 32         | 4                      | 33         |
| Black marlin                        | *             | 1          | *             | *          | *                      | 1          |
| Spearfish & sailfish                | *             | 3          | 1             | 3          | 1                      | 6          |
| Total billfishes                    | 3             | 26         | 11            | 76         | 14                     | 102        |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 6.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1969. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 1             | 6          | 22            | 165        | 23                     | 171        |
| February                            | 5             | 31         | 11            | 56         | 16                     | 87         |
| March                               | 5             | 32         | 7             | 39         | 12                     | 71         |
| April                               | 1             | 5          | 4             | 32         | 5                      | 37         |
| May                                 | *             | 2          | 1             | 7          | 1                      | 9          |
| June                                | 0             | 0          | 2             | 16         | 2                      | 16         |
| July                                | 1             | 6          | 1             | 11         | 2                      | 17         |
| August                              | *             | 2          | 3             | 21         | 3                      | 23         |
| September                           | 0             | 0          | 0             | 0          | 0                      | 0          |
| October                             | 1             | 5          | 3             | 11         | 4                      | 16         |
| November                            | 1             | 6          | 3             | 21         | 4                      | 27         |
| December                            | 4             | 24         | 6             | 33         | 10                     | 57         |
| Total                               | 19            | 119        | 63            | 412        | 82                     | 531        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 2             | 10         | 9             | 79         | 11                     | 89         |
| Yellowfin tuna                      | 6             | 42         | 14            | 71         | 20                     | 113        |
| Bigeye tuna                         | 5             | 34         | 14            | 72         | 19                     | 106        |
| Bluefin tuna                        | 0             | 0          | *             | *          | *                      | *          |
| Skipjack tuna                       | *             | *          | *             | *          | *                      | *          |
| Total tunas                         | 13            | 86         | 37            | 222        | 50                     | 308        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 1             | 7          | 3             | 17         | 4                      | 24         |
| Striped marlin                      | *             | 1          | 2             | 13         | 2                      | 14         |
| Swordfish                           | *             | 1          | 2             | 17         | 2                      | 18         |
| Black marlin                        | *             | 1          | *             | 1          | *                      | 2          |
| Spearfish & sailfish                | *             | *          | *             | 1          | *                      | 1          |
| Total billfishes                    | 1             | 10         | 7             | 49         | 8                      | 59         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 7.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1970. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 4             | 24         | 8             | 54         | 12                     | 78         |
| February                            | 4             | 24         | 22            | 167        | 26                     | 191        |
| March                               | 2             | 15         | 42            | 226        | 44                     | 241        |
| April                               | 1             | 7          | 8             | 64         | 9                      | 71         |
| May                                 | 3             | 16         | 7             | 66         | 10                     | 82         |
| June                                | 1             | 7          | 7             | 66         | 8                      | 73         |
| July                                | 1             | 3          | 1             | 5          | 2                      | 8          |
| August                              | 1             | 7          | 5             | 27         | 6                      | 34         |
| September                           | 2             | 12         | 4             | 23         | 6                      | 35         |
| October                             | 2             | 13         | 8             | 45         | 10                     | 58         |
| November                            | 1             | 4          | 9             | 39         | 10                     | 43         |
| December                            | 0             | 1          | 25            | 88         | 25                     | 89         |
| Total                               | 22            | 133        | 146           | 870        | 168                    | 1003       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 1             | 7          | 17            | 92         | 18                     | 99         |
| Yellowfin tuna                      | 10            | 68         | 44            | 220        | 54                     | 288        |
| Bigeye tuna                         | 4             | 26         | 14            | 85         | 18                     | 111        |
| Bluefin tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Skipjack tuna                       | *             | *          | 1             | 4          | 1                      | 4          |
| Total tunas                         | 15            | 101        | 76            | 401        | 91                     | 502        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 2             | 13         | 11            | 63         | 13                     | 76         |
| Striped marlin                      | *             | 1          | 9             | 71         | 9                      | 72         |
| Swordfish                           | *             | 1          | 5             | 37         | 5                      | 38         |
| Black marlin                        | *             | *          | *             | 3          | *                      | 3          |
| Spearfish & sailfish                | *             | 1          | 3             | 16         | 3                      | 17         |
| Total billfishes                    | 2             | 16         | 28            | 190        | 30                     | 206        |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.



Table 8.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1971. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 0             | 1          | 2             | 17         | 2                      | 18         |
| February                            | 0             | 1          | 13            | 123        | 13                     | 124        |
| March                               | 0             | 0          | 18            | 176        | 18                     | 176        |
| April                               | 0             | 0          | 4             | 59         | 4                      | 59         |
| May                                 | 0             | 0          | *             | 5          | *                      | 5          |
| June                                | 0             | 0          | 1             | 21         | 1                      | 21         |
| July                                | 0             | 0          | 2             | 12         | 2                      | 12         |
| August                              | 0             | 0          | 1             | 19         | 1                      | 19         |
| September                           | 0             | 0          | 47            | 72         | 47                     | 72         |
| October                             | 0             | 0          | 113           | 136        | 113                    | 136        |
| November                            | 13            | 17         | 54            | 99         | 67                     | 116        |
| December                            | 0             | 0          | 64            | 282        | 64                     | 282        |
| Total                               | 13            | 19         | 319           | 1021       | 332                    | 1040       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 0             | *          | 71            | 178        | 71                     | 178        |
| Yellowfin tuna                      | 6             | 8          | 95            | 216        | 101                    | 224        |
| Bigeye tuna                         | 1             | 1          | 20            | 97         | 21                     | 98         |
| Bluefin tuna                        | 0             | 0          | *             | *          | *                      | *          |
| Skipjack tuna                       | *             | *          | *             | *          | *                      | *          |
| Total tunas                         | 7             | 9          | 186           | 491        | 193                    | 500        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 2             | 2          | 20            | 54         | 22                     | 56         |
| Striped marlin                      | *             | *          | 6             | 48         | 6                      | 48         |
| Swordfish                           | *             | *          | 4             | 28         | 4                      | 28         |
| Black marlin                        | 0             | 0          | 2             | 5          | 2                      | 5          |
| Spearfish & sailfish                | 0             | 0          | 2             | 17         | 2                      | 17         |
| Total billfishes                    | 2             | 2          | 34            | 152        | 36                     | 154        |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 9.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1972. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 0             | 0          | 59            | 151        | 59                     | 151        |
| February                            | 0             | 1          | 23            | 65         | 23                     | 66         |
| March                               | 0             | 1          | 4             | 37         | 4                      | 38         |
| April                               | 0             | 0          | 5             | 42         | 5                      | 42         |
| May                                 | 0             | 15         | 2             | 14         | 2                      | 29         |
| June                                | 0             | 2          | 16            | 37         | 16                     | 39         |
| July                                | 0             | 0          | 2             | 12         | 2                      | 12         |
| August                              | 0             | 0          | 25            | 29         | 25                     | 29         |
| September                           | 0             | 1          | 30            | 39         | 30                     | 40         |
| October                             | 0             | 0          | 25            | 54         | 25                     | 54         |
| November                            | 0             | 0          | 19            | 44         | 19                     | 44         |
| December                            | 0             | 0          | 30            | 69         | 30                     | 69         |
| Total                               | 0             | 20         | 240           | 593        | 240                    | 613        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 0             | *          | 82            | 168        | 82                     | 168        |
| Yellowfin tuna                      | 0             | 5          | 70            | 111        | 70                     | 116        |
| Bigeye tuna                         | 0             | 6          | 14            | 48         | 14                     | 54         |
| Bluefin tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Skipjack tuna                       | 0             | 0          | 1             | 1          | 1                      | 1          |
| Total tunas                         | 0             | 11         | 167           | 328        | 167                    | 339        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 0             | 2          | 8             | 22         | 8                      | 24         |
| Striped marlin                      | 0             | *          | 3             | 20         | 3                      | 20         |
| Swordfish                           | 0             | *          | 4             | 20         | 4                      | 20         |
| Black marlin                        | 0             | 0          | 1             | 2          | 1                      | 2          |
| Spearfish & sailfish                | 0             | 0          | 5             | 9          | 5                      | 9          |
| Total billfishes                    | 0             | 2          | 21            | 73         | 21                     | 75         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 10.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1973. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 0             | 0          | 16            | 23         | 16                     | 23         |
| February                            | 0             | 8          | 3             | 26         | 3                      | 34         |
| March                               | *             | 5          | 4             | 46         | 4                      | 51         |
| April                               | *             | 9          | 1             | 5          | 1                      | 14         |
| May                                 | 0             | 3          | *             | 2          | *                      | 5          |
| June                                | 4             | 10         | 3             | 16         | 7                      | 26         |
| July                                | 0             | 12         | *             | 2          | *                      | 14         |
| August                              | 0             | 0          | 1             | 11         | 1                      | 11         |
| September                           | 0             | 0          | 1             | 6          | 1                      | 6          |
| October                             | *             | 3          | 0             | 1          | *                      | 4          |
| November                            | 0             | 5          | 8             | 34         | 8                      | 39         |
| December                            | 0             | 0          | 6             | 61         | 6                      | 61         |
| Total                               | 4             | 55         | 43            | 233        | 47                     | 288        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 1             | 5          | 22            | 100        | 23                     | 105        |
| Yellowfin tuna                      | 1             | 22         | 3             | 21         | 4                      | 43         |
| Bigeye tuna                         | 1             | 17         | 3             | 24         | 4                      | 41         |
| Bluefin tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Skipjack tuna                       | 0             | 0          | *             | *          | *                      | *          |
| Total tunas                         | 3             | 44         | 28            | 145        | 31                     | 189        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | *             | 7          | 1             | 7          | 1                      | 14         |
| Striped marlin                      | *             | 1          | 1             | 11         | 1                      | 12         |
| Swordfish                           | *             | 1          | 1             | 9          | 1                      | 10         |
| Black marlin                        | 0             | 0          | *             | *          | *                      | *          |
| Spearfish & sailfish                | *             | *          | *             | *          | *                      | *          |
| Total billfishes                    | *             | 9          | 3             | 27         | 3                      | 36         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 11.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1974. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | *             | 4          | 1             | 5          | 1                      | 9          |
| February                            | 0             | 23         | 5             | 51         | 5                      | 74         |
| March                               | 7             | 97         | 6             | 62         | 13                     | 159        |
| April                               | 11            | 21         | 18            | 103        | 29                     | 124        |
| May                                 | *             | 44         | 7             | 59         | 7                      | 103        |
| June                                | 0             | 13         | 2             | 31         | 2                      | 44         |
| July                                | 0             | 6          | 0             | 0          | 0                      | 6          |
| August                              | 0             | 0          | *             | 1          | *                      | 1          |
| September                           | *             | 23         | 0             | 0          | *                      | 23         |
| October                             | 0             | 42         | 0             | 7          | 0                      | 49         |
| November                            | 0             | 0          | 0             | 15         | 0                      | 15         |
| December                            | 0             | *          | *             | 3          | *                      | 3          |
| Total                               | 18            | 273        | 39            | 337        | 57                     | 610        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 1             | 70         | 1             | 20         | 2                      | 90         |
| Yellowfin tuna                      | 13            | 111        | 4             | 28         | 17                     | 139        |
| Bigeye tuna                         | 6             | 53         | 5             | 23         | 11                     | 76         |
| Bluefin tuna                        | 0             | 0          | *             | *          | *                      | *          |
| Skipjack tuna                       | 0             | *          | *             | *          | *                      | *          |
| Total tunas                         | 20            | 234        | 10            | 71         | 30                     | 305        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 1             | 27         | 2             | 19         | 3                      | 46         |
| Striped marlin                      | *             | 3          | 6             | 63         | 6                      | 66         |
| Swordfish                           | *             | 2          | 4             | 29         | 4                      | 31         |
| Black marlin                        | 0             | *          | *             | *          | *                      | *          |
| Spearfish & sailfish                | *             | 4          | *             | 2          | *                      | 6          |
| Total billfishes                    | 1             | 36         | 12            | 113        | 13                     | 149        |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.



Table 12.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1975. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 0             | 23         | 5             | 42         | 5                      | 65         |
| February                            | 0             | 17         | 7             | 61         | 7                      | 78         |
| March                               | 2             | 25         | 12            | 99         | 14                     | 124        |
| April                               | 6             | 27         | 17            | 36         | 23                     | 63         |
| May                                 | 0             | 0          | 2             | 21         | 2                      | 21         |
| June                                | 0             | 0          | *             | 1          | *                      | 1          |
| July                                | 2             | 20         | 1             | 4          | 3                      | 24         |
| August                              | *             | 2          | 3             | 3          | 3                      | 5          |
| September                           | *             | 23         | 5             | 6          | 5                      | 29         |
| October                             | 10            | 133        | 3             | 41         | 13                     | 174        |
| November                            | 0             | 2          | 2             | 16         | 2                      | 18         |
| December                            | 0             | 6          | 1             | 12         | 1                      | 16         |
| Total                               | 20            | 278        | 58            | 342        | 78                     | 620        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 5             | 58         | 14            | 90         | 19                     | 148        |
| Yellowfin tuna                      | 7             | 100        | 7             | 48         | 14                     | 148        |
| Bigeye tuna                         | 2             | 44         | 3             | 30         | 5                      | 74         |
| Bluefin tuna                        | 0             | 0          | *             | 1          | *                      | 1          |
| Skipjack tuna                       | *             | *          | *             | *          | *                      | *          |
| Total tunas                         | 14            | 202        | 24            | 169        | 38                     | 371        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 3             | 36         | 3             | 14         | 6                      | 50         |
| Striped marlin                      | *             | *          | 3             | 21         | 3                      | 21         |
| Swordfish                           | *             | 1          | 5             | 36         | 5                      | 37         |
| Black marlin                        | 0             | *          | *             | *          | *                      | *          |
| Spearfish & sailfish                | 0             | *          | *             | 1          | *                      | 1          |
| Total billfishes                    | 3             | 37         | 11            | 72         | 14                     | 109        |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 13.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1976. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 10            | 60         | 13            | 88         | 23                     | 148        |
| February                            | 6             | 36         | 9             | 57         | 15                     | 93         |
| March                               | 2             | 13         | 6             | 44         | 8                      | 57         |
| April                               | 5             | 30         | 5             | 21         | 10                     | 51         |
| May                                 | 1             | 7          | 1             | 5          | 2                      | 12         |
| June                                | 1             | 7          | 1             | 7          | 2                      | 14         |
| July                                | 6             | 39         | 3             | 13         | 9                      | 52         |
| August                              | 5             | 30         | 5             | 27         | 10                     | 57         |
| September                           | 5             | 30         | 4             | 25         | 9                      | 55         |
| October                             | 11            | 65         | 5             | 37         | 16                     | 102        |
| November                            | 31            | 192        | 18            | 127        | 49                     | 319        |
| December                            | 37            | 226        | 13            | 49         | 50                     | 275        |
| Total                               | 120           | 735        | 83            | 500        | 203                    | 1235       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 14            | 90         | 13            | 91         | 27                     | 181        |
| Yellowfin tuna                      | 93            | 577        | 44            | 190        | 137                    | 767        |
| Bigeye tuna                         | 41            | 252        | 21            | 95         | 62                     | 347        |
| Bluefin tuna                        | 0             | *          | *             | *          | *                      | *          |
| Skipjack tuna                       | *             | 3          | *             | 1          | *                      | 4          |
| Total tunas                         | 148           | 922        | 78            | 377        | 226                    | 1299       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 9             | 58         | 6             | 32         | 15                     | 90         |
| Striped marlin                      | *             | 2          | 1             | 8          | 1                      | 10         |
| Swordfish                           | 2             | 10         | 3             | 20         | 5                      | 30         |
| Black marlin                        | *             | 1          | *             | 1          | *                      | 2          |
| Spearfish & sailfish                | *             | 2          | *             | 2          | *                      | 4          |
| Total billfishes                    | 11            | 73         | 10            | 63         | 21                     | 136        |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 14.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1977. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 17            | 106        | 14            | 77         | 31                     | 183        |
| February                            | 5             | 34         | 8             | 48         | 13                     | 82         |
| March                               | 11            | 69         | 12            | 70         | 23                     | 139        |
| April                               | 8             | 48         | 5             | 20         | 13                     | 68         |
| May                                 | 29            | 183        | 20            | 83         | 49                     | 266        |
| June                                | 26            | 168        | 34            | 137        | 60                     | 305        |
| July                                | 20            | 130        | 25            | 108        | 45                     | 238        |
| August                              | 8             | 52         | 10            | 45         | 18                     | 97         |
| September                           | 13            | 80         | 15            | 64         | 28                     | 144        |
| October                             | 22            | 136        | 17            | 74         | 39                     | 210        |
| November                            | 24            | 152        | 21            | 94         | 45                     | 246        |
| December                            | 7             | 41         | 9             | 57         | 16                     | 98         |
| Total                               | 190           | 1199       | 190           | 877        | 380                    | 2076       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 7             | 49         | 12            | 109        | 19                     | 158        |
| Yellowfin tuna                      | 217           | 1368       | 208           | 861        | 425                    | 2229       |
| Bigeye tuna                         | 90            | 572        | 94            | 406        | 184                    | 978        |
| Bluefin tuna                        | *             | *          | *             | 1          | *                      | 1          |
| Skipjack tuna                       | *             | *          | *             | *          | *                      | *          |
| Total tunas                         | 314           | 1989       | 314           | 1377       | 628                    | 3366       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 14            | 87         | 15            | 63         | 29                     | 150        |
| Striped marlin                      | *             | 1          | *             | 2          | *                      | 3          |
| Swordfish                           | 1             | 9          | 2             | 13         | 3                      | 22         |
| Black marlin                        | 1             | 5          | 1             | 4          | 2                      | 9          |
| Spearfish & sailfish                | *             | 2          | *             | 1          | *                      | 3          |
| Total billfishes                    | 16            | 104        | 18            | 83         | 34                     | 187        |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 15.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1978.

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 8             | 39         | *             | 26         | 8                      | 65         |
| February                            | 2             | 34         | 17            | 225        | 19                     | 259        |
| March                               | *             | 11         | *             | 12         | *                      | 23         |
| April                               | *             | 5          | *             | 11         | *                      | 16         |
| May                                 | 8             | 52         | *             | 8          | 8                      | 60         |
| June                                | 2             | 9          | 3             | 4          | 5                      | 13         |
| July                                | 9             | 67         | 5             | 30         | 14                     | 97         |
| August                              | 8             | 73         | 18            | 56         | 26                     | 129        |
| September                           | 14            | 37         | 2             | 7          | 16                     | 44         |
| October                             | *             | 28         | 3             | 17         | 3                      | 45         |
| November                            | 1             | 66         | *             | 19         | 1                      | 85         |
| December                            | 1             | 23         | 5             | 17         | 6                      | 40         |
| Total                               | 53            | 444        | 53            | 432        | 106                    | 876        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | *             | 13         | 5             | 80         | 5                      | 93         |
| Yellowfin tuna                      | 83            | 540        | 34            | 440        | 117                    | 980        |
| Bigeye tuna                         | 12            | 86         | 6             | 46         | 18                     | 132        |
| Bluefin tuna                        | *             | *          | *             | *          | *                      | *          |
| Skipjack tuna                       | *             | *          | *             | *          | *                      | *          |
| Total tunas                         | 95            | 639        | 45            | 566        | 140                    | 1,205      |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 4             | 30         | 2             | 16         | 6                      | 46         |
| Striped marlin                      | *             | *          | *             | 3          | *                      | 3          |
| Swordfish                           | 1             | 5          | 1             | 5          | 2                      | 10         |
| Black marlin                        | *             | 2          | *             | *          | *                      | 2          |
| Spearfish & sailfish                | *             | *          | *             | 5          | *                      | 5          |
| Total billfishes                    | 5             | 37         | 3             | 29         | 8                      | 66         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.



Table 16.--Estimated catch and effort by Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1979.

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | *             | 4          | 4             | 11         | 4                      | 15         |
| February                            | *             | 2          | 25            | 70         | 25                     | 72         |
| March                               | 3             | 13         | 2             | 23         | 5                      | 36         |
| April                               | 1             | 19         | *             | 2          | 1                      | 21         |
| May                                 | *             | 13         | 1             | 6          | 1                      | 19         |
| June                                | 3             | 32         | 5             | 22         | 8                      | 54         |
| July                                | 3             | 17         | 1             | 20         | 4                      | 37         |
| August                              | 3             | 4          | 1             | 3          | 4                      | 7          |
| September                           | 1             | 19         | *             | 16         | 1                      | 35         |
| October                             | 5             | 21         | 1             | 4          | 6                      | 25         |
| November                            | 1             | 15         | 4             | 14         | 5                      | 29         |
| December                            | *             | *          | *             | *          | *                      | *          |
| Total                               | 20            | 159        | 44            | 191        | 64                     | 350        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | *             | 5          | 11            | 28         | 11                     | 33         |
| Yellowfin tuna                      | 10            | 126        | 30            | 119        | 40                     | 245        |
| Bigeye tuna                         | 4             | 30         | 7             | 28         | 11                     | 58         |
| Bluefin tuna                        | *             | *          | *             | *          | *                      | *          |
| Skipjack tuna                       | *             | *          | *             | *          | *                      | *          |
| Total tunas                         | 14            | 161        | 48            | 175        | 62                     | 336        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Blue marlin                         | 1             | 10         | 1             | 12         | 2                      | 22         |
| Striped marlin                      | *             | 1          | *             | 5          | *                      | 6          |
| Swordfish                           | *             | 2          | 1             | 5          | 1                      | 7          |
| Black marlin                        | *             | 1          | *             | 1          | *                      | 2          |
| Spearfish & sailfish                | *             | 1          | *             | 1          | *                      | 2          |
| Total billfishes                    | 1             | 15         | 2             | 24         | 3                      | 39         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 17.--Total tuna catch, effort, and catch per unit effort (CPUE) for Japanese longline vessels around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1965-79.

| Year | Guam               |                     |                   | CNMI               |                     |                   |
|------|--------------------|---------------------|-------------------|--------------------|---------------------|-------------------|
|      | Catch <sup>1</sup> | Effort <sup>2</sup> | CPUE <sup>3</sup> | Catch <sup>1</sup> | Effort <sup>2</sup> | CPUE <sup>3</sup> |
| 1965 | 249                | 275                 | 0.91              | 248                | 603                 | 0.41              |
| 1966 | 174                | 226                 | 0.77              | 169                | 309                 | 0.55              |
| 1967 | 89                 | 166                 | 0.55              | 207                | 468                 | 0.44              |
| 1968 | 165                | 214                 | 0.77              | 199                | 485                 | 0.41              |
| 1969 | 86                 | 119                 | 0.72              | 222                | 412                 | 0.54              |
| 1970 | 101                | 133                 | 0.76              | 401                | 870                 | 0.46              |
| 1971 | 9                  | 18                  | 0.50              | 491                | 1,022               | 0.48              |
| 1972 | 11                 | 20                  | 0.55              | 328                | 592                 | 0.55              |
| 1973 | 44                 | 55                  | 0.80              | 145                | 232                 | 0.63              |
| 1974 | 234                | 275                 | 0.85              | 71                 | 337                 | 0.21              |
| 1975 | 202                | 278                 | 0.73              | 167                | 341                 | 0.49              |
| 1976 | 626                | 505                 | 1.24              | 91                 | 129                 | 0.71              |
| 1977 | 1,334              | 847                 | 1.58              | 576                | 364                 | 1.58              |
| 1978 | 639                | 445                 | 1.44              | 566                | 434                 | 1.30              |
| 1979 | 161                | 158                 | 1.02              | 175                | 191                 | 0.92              |

<sup>1</sup>Catch in metric tons.

<sup>2</sup>Effort in vessel days.

<sup>3</sup>CPUE in metric tons per vessel day.

Table 18.--Catches (in metric tons) of albacore, yellowfin, and bigeye tunas from Japanese longliners around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1965-79.

| Year | Guam           |                   |                | CNMI     |                   |                |
|------|----------------|-------------------|----------------|----------|-------------------|----------------|
|      | Albacore       | Yellowfin<br>tuna | Bigeye<br>tuna | Albacore | Yellowfin<br>tuna | Bigeye<br>tuna |
| 1965 | 48             | 160               | 41             | 55       | 95                | 96             |
| 1966 | 17             | 126               | 31             | 28       | 106               | 34             |
| 1967 | 3              | 42                | 44             | 9        | 16                | 20             |
| 1968 | 12             | 104               | 48             | 95       | 52                | 52             |
| 1969 | 10             | 42                | 34             | 79       | 71                | 72             |
| 1970 | 7              | 68                | 26             | 92       | 220               | 85             |
| 1971 | <sup>1</sup> * | 8                 | 1              | 178      | 216               | 97             |
| 1972 | <sup>1</sup> * | 5                 | 6              | 168      | 111               | 48             |
| 1973 | 5              | 22                | 17             | 100      | 21                | 24             |
| 1974 | 70             | 111               | 53             | 20       | 28                | 23             |
| 1975 | 58             | 100               | 44             | 88       | 48                | 30             |
| 1976 | 109            | 361               | 153            | 33       | 44                | 13             |
| 1977 | 62             | 892               | 380            | 34       | 363               | 179            |
| 1978 | 13             | 540               | 86             | 80       | 440               | 46             |
| 1979 | 5              | 126               | 30             | 28       | 119               | 28             |

<sup>1</sup> < 1 mt.

Table 19.--Annual catch,<sup>1</sup> effort,<sup>2</sup> and catch per unit effort (CPUE)<sup>3</sup> for total tunas from longliners by latitude around Guam and the Commonwealth of the Northern Mariana Islands, 1971-79.

| Lat. N | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 |
|--------|------|------|------|------|------|------|------|------|------|
| 20-24  | 94   | 74   | 82   | 29   | 82   | 9    | 18   | 35   | 17   |
|        | 454  | 229  | 146  | 264  | 237  | 13   | 24   | 74   | 49   |
|        | 0.2  | 0.3  | 0.6  | 0.1  | 0.4  | 0.7  | 0.8  | 0.5  | 0.3  |
| 19-20  | 105  | 42   | 36   | 1    | 9    | 5    | 34   | 41   | 13   |
|        | 179  | 85   | 48   | 6    | 19   | 9    | 26   | 40   | 12   |
|        | 0.6  | 0.5  | 0.7  | 0.2  | 0.5  | 0.6  | 1.3  | 1.0  | 1.1  |
| 18-19  | 151  | 77   | 23   | 12   | 9    | 1    | 6    | 254  | 47   |
|        | 184  | 98   | 31   | 19   | 10   | 2    | 10   | 152  | 34   |
|        | 0.8  | 0.8  | 0.7  | 0.6  | 0.9  | 0.5  | 0.6  | 1.7  | 1.4  |
| 17-18  | 72   | 73   | 3    | 8    | 8    | 2    | 12   | 29   | 3    |
|        | 104  | 93   | 4    | 16   | 9    | 3    | 18   | 18   | 5    |
|        | 0.7  | 0.8  | 0.7  | 0.5  | 0.9  | 0.7  | 0.7  | 1.6  | 0.6  |
| 16-17  | 51   | 45   | 0    | 2    | 22   | 5    | 90   | 27   | 0    |
|        | 70   | 56   | 0    | 6    | 17   | 10   | 63   | 23   | 2    |
|        | 0.7  | 0.8  | 0    | 0.4  | 1.3  | 0.5  | 1.4  | 1.2  | 0.0  |
| 15-16  | 6    | 13   | 0    | 3    | 4    | 41   | 71   | 80   | 4    |
|        | 13   | 24   | 0    | 6    | 6    | 60   | 45   | 61   | 6    |
|        | 0.4  | 0.5  | 0    | 0.5  | 0.7  | 0.7  | 1.6  | 1.3  | 0.7  |
| 14-15  | 9    | 0    | 4    | 12   | 21   | 104  | 130  | 106  | 33   |
|        | 10   | 0    | 10   | 20   | 38   | 105  | 99   | 97   | 41   |
|        | 0.9  | 0    | 0.4  | 0.6  | 0.5  | 1.0  | 1.3  | 1.1  | 0.8  |
| 13-14  | 11   | 4    | 16   | 113  | 66   | 230  | 422  | 127  | 92   |
|        | 23   | 8    | 24   | 91   | 80   | 182  | 249  | 72   | 99   |
|        | 0.5  | 0.5  | 0.7  | 1.2  | 0.8  | 1.3  | 1.7  | 1.8  | 0.9  |
| 12-13  | 1    | 9    | 20   | 50   | 43   | 226  | 642  | 285  | 65   |
|        | 3    | 14   | 16   | 76   | 64   | 173  | 368  | 199  | 58   |
|        | 0.3  | 0.7  | 1.3  | 0.7  | 0.7  | 1.3  | 1.7  | 1.4  | 1.1  |
| 11-12  | 0    | 2    | 5    | 75   | 105  | 94   | 485  | 220  | 63   |
|        | 0    | 5    | 8    | 108  | 139  | 78   | 307  | 144  | 47   |
|        | 0    | 0.4  | 0.6  | 0.7  | 0.8  | 1.2  | 1.6  | 1.5  | 1.3  |

<sup>1</sup>Catch in metric tons.

<sup>2</sup>Effort in vessel days.

<sup>3</sup>CPUE in metric tons per vessel day



Table 20.--Monthly Japanese longline catches (in metric tons) around Guam and the Commonwealth of the Northern Mariana Islands (CNMI) for two periods, 1971-75 and 1976-79.

| Month     | 1971-75 |      | 1976-79 |      |
|-----------|---------|------|---------|------|
|           | Guam    | CNMI | Guam    | CNMI |
| January   | 20      | 154  | 163     | 109  |
| February  | 42      | 85   | 122     | 379  |
| March     | 89      | 134  | 105     | 73   |
| April     | 39      | 44   | 109     | 37   |
| May       | 41      | 13   | 378     | 131  |
| June      | 8       | 15   | 202     | 130  |
| July      | 24      | 4    | 336     | 180  |
| August    | 1       | 28   | 150     | 88   |
| September | 38      | 69   | 117     | 33   |
| October   | 178     | 199  | 283     | 68   |
| November  | 14      | 132  | 443     | 115  |
| December  | 4       | 321  | 347     | 68   |

Table 21.--Estimated catch and effort by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1970. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 1             | 13         | 3             | 38         | 4                      | 51         |
| February                            | 0             | 20         | 8             | 28         | 8                      | 48         |
| March                               | 2             | 71         | 12            | 52         | 14                     | 123        |
| April                               | 2             | 15         | 28            | 65         | 30                     | 80         |
| May                                 | *             | 4          | 14            | 35         | 14                     | 39         |
| June                                | 0             | 0          | 9             | 53         | 9                      | 53         |
| July                                | 0             | 1          | 207           | 602        | 207                    | 603        |
| August                              | *             | 5          | 78            | 229        | 78                     | 234        |
| September                           | 5             | 28         | 101           | 207        | 106                    | 235        |
| October                             | 0             | 4          | 21            | 54         | 21                     | 58         |
| November                            | 1             | 14         | 41            | 292        | 42                     | 306        |
| December                            | 2             | 7          | 3             | 107        | 5                      | 114        |
| Total                               | 13            | 182        | 525           | 1762       | 538                    | 1944       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 0             | 0          | *             | 14         | *                      | 14         |
| Yellowfin tuna                      | *             | 16         | 54            | 414        | 54                     | 430        |
| Bigeye tuna                         | 0             | *          | 35            | 153        | 35                     | 153        |
| Bluefin tuna                        | 0             | 0          | 1             | 4          | 1                      | 4          |
| Skipjack tuna                       | 28            | 649        | 2903          | 8284       | 2931                   | 8933       |
| Total tunas                         | 28            | 665        | 2993          | 8869       | 3021                   | 9534       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Frigate tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Others                              | *             | *          | 3             | 13         | 3                      | 13         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 22.--Estimated catch and effort by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1971. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | *             | 20         | 4             | 38         | 4                      | 58         |
| February                            | *             | 24         | 20            | 74         | 20                     | 98         |
| March                               | 2             | 14         | 14            | 66         | 16                     | 80         |
| April                               | 0             | 1          | 1             | 7          | 1                      | 8          |
| May                                 | 0             | 0          | 0             | 8          | 0                      | 8          |
| June                                | 0             | 0          | 14            | 31         | 14                     | 31         |
| July                                | 0             | 1          | 194           | 678        | 194                    | 679        |
| August                              | 4             | 6          | 218           | 562        | 222                    | 568        |
| September                           | 3             | 15         | 255           | 564        | 258                    | 579        |
| October                             | 11            | 44         | 178           | 419        | 189                    | 463        |
| November                            | 0             | 30         | 27            | 173        | 27                     | 203        |
| December                            | 1             | 9          | 4             | 26         | 5                      | 35         |
| Total                               | 21            | 164        | 929           | 2646       | 950                    | 2810       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 0             | 0          | 0             | 2          | 0                      | 2          |
| Yellowfin tuna                      | *             | 46         | 38            | 184        | 38                     | 230        |
| Bigeye tuna                         | 0             | 0          | 0             | 0          | 0                      | 0          |
| Bluefin tuna                        | 0             | 0          | 0             | 12         | 0                      | 12         |
| Skipjack tuna                       | 78            | 398        | 4454          | 12366      | 4532                   | 12764      |
| Total tunas                         | 78            | 444        | 4492          | 12564      | 4570                   | 13008      |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Frigate tuna                        | 0             | 0          | *             | *          | *                      | *          |
| Others                              | 0             | 1          | 1             | 19         | 1                      | 20         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 23.--Estimated catch and effort by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1972. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 1             | 4          | 5             | 17         | 6                      | 21         |
| February                            | 0             | 2          | 9             | 20         | 9                      | 22         |
| March                               | *             | 2          | 10            | 28         | 10                     | 30         |
| April                               | 0             | 2          | 12            | 47         | 12                     | 49         |
| May                                 | 1             | 1          | 3             | 8          | 4                      | 9          |
| June                                | 0             | 0          | 97            | 299        | 97                     | 299        |
| July                                | 3             | 10         | 251           | 527        | 254                    | 537        |
| August                              | 9             | 18         | 188           | 487        | 197                    | 505        |
| September                           | 9             | 17         | 47            | 116        | 56                     | 133        |
| October                             | 2             | 12         | 14            | 45         | 16                     | 57         |
| November                            | 16            | 31         | 10            | 46         | 26                     | 77         |
| December                            | 6             | 19         | *             | 8          | 6                      | 27         |
| Total                               | 47            | 118        | 646           | 1648       | 693                    | 1766       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 3             | 13         | 23            | 52         | 26                     | 65         |
| Yellowfin tuna                      | 0             | 4          | 17            | 66         | 17                     | 70         |
| Bigeye tuna                         | 0             | 0          | 4             | 16         | 4                      | 16         |
| Bluefin tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Skipjack tuna                       | 131           | 284        | 2885          | 6971       | 3016                   | 7255       |
| Total tunas                         | 134           | 301        | 2929          | 7105       | 3063                   | 7406       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Frigate tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Others                              | 1             | 1          | 1             | 2          | 2                      | 3          |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.



Table 24.--Estimated catch and effort by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1973. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 0             | 2          | 0             | 13         | 0                      | 15         |
| February                            | *             | 2          | 3             | 18         | 3                      | 20         |
| March                               | 0             | 8          | 6             | 73         | 6                      | 81         |
| April                               | 0             | 6          | 7             | 32         | 7                      | 38         |
| May                                 | 0             | 0          | 4             | 14         | 4                      | 14         |
| June                                | 0             | 0          | 13            | 41         | 13                     | 41         |
| July                                | 0             | 5          | 233           | 532        | 233                    | 537        |
| August                              | 8             | 15         | 202           | 470        | 210                    | 485        |
| September                           | 4             | 4          | 49            | 134        | 53                     | 138        |
| October                             | 0             | 1          | 16            | 54         | 16                     | 55         |
| November                            | 1             | 2          | 64            | 140        | 65                     | 142        |
| December                            | *             | 9          | 27            | 82         | 27                     | 91         |
| Total                               | 13            | 54         | 624           | 1603       | 637                    | 1657       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 0             | 0          | 9             | 11         | 9                      | 11         |
| Yellowfin tuna                      | 7             | 10         | 36            | 258        | 43                     | 268        |
| Bigeye tuna                         | 0             | 1          | 0             | 6          | 0                      | 7          |
| Bluefin tuna                        | 0             | 0          | 0             | 4          | 0                      | 4          |
| Skipjack tuna                       | 78            | 223        | 3030          | 7099       | 3108                   | 7322       |
| Total tunas                         | 85            | 234        | 3075          | 7378       | 3160                   | 7612       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Frigate tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Others                              | 0             | 0          | *             | 2          | *                      | 2          |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 25.--Estimated catch and effort by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1974. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | *             | 6          | 26            | 34         | 26                     | 40         |
| February                            | 0             | 3          | 15            | 74         | 15                     | 77         |
| March                               | *             | 3          | 2             | 55         | 2                      | 58         |
| April                               | 0             | 3          | 20            | 45         | 20                     | 48         |
| May                                 | 0             | 0          | 0             | 0          | 0                      | 0          |
| June                                | 0             | 0          | 7             | 26         | 7                      | 26         |
| July                                | 5             | 11         | 195           | 556        | 200                    | 567        |
| August                              | 0             | 2          | 23            | 59         | 23                     | 61         |
| September                           | 3             | 17         | 63            | 127        | 66                     | 144        |
| October                             | 2             | 11         | 107           | 199        | 109                    | 210        |
| November                            | 1             | 8          | 39            | 138        | 40                     | 146        |
| December                            | 1             | 3          | 28            | 62         | 29                     | 65         |
| Total                               | 12            | 67         | 525           | 1375       | 537                    | 1442       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 0             | 0          | 1             | 1          | 1                      | 1          |
| Yellowfin tuna                      | 0             | 7          | 101           | 294        | 101                    | 301        |
| Bigeye tuna                         | 0             | 0          | 0             | 0          | 0                      | 0          |
| Bluefin tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Skipjack tuna                       | 8             | 76         | 1798          | 4627       | 1806                   | 4703       |
| Total tunas                         | 8             | 83         | 1900          | 4922       | 1908                   | 5005       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Frigate tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Others                              | 0             | 0          | 23            | 39         | 23                     | 39         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 26.--Estimated catch and effort by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1975. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 0             | 1          | 15            | 44         | 15                     | 45         |
| February                            | 1             | 3          | 22            | 36         | 23                     | 39         |
| March                               | 3             | 20         | 35            | 81         | 38                     | 101        |
| April                               | 4             | 21         | 66            | 137        | 70                     | 158        |
| May                                 | 2             | 77         | 5             | 30         | 7                      | 107        |
| June                                | 1             | 9          | 188           | 191        | 189                    | 400        |
| July                                | 1             | 10         | 85            | 254        | 86                     | 264        |
| August                              | *             | 8          | 132           | 260        | 132                    | 268        |
| September                           | 1             | 22         | 51            | 154        | 52                     | 176        |
| October                             | *             | 8          | 4             | 56         | 4                      | 64         |
| November                            | 1             | 10         | 52            | 151        | 53                     | 161        |
| December                            | 1             | 17         | 38            | 102        | 39                     | 119        |
| Total                               | 15            | 206        | 693           | 1696       | 708                    | 1902       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 0             | 0          | 0             | 4          | 0                      | 4          |
| Yellowfin tuna                      | 0             | 9          | 82            | 271        | 82                     | 280        |
| Bigeye tuna                         | 0             | 1          | 2             | 6          | 2                      | 7          |
| Bluefin tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Skipjack tuna                       | 68            | 1117       | 2867          | 6345       | 2935                   | 7462       |
| Total tunas                         | 68            | 1127       | 2951          | 6626       | 3019                   | 7753       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Frigate tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Others                              | 0             | 3          | 16            | 31         | 16                     | 34         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 27.--Estimated catch and effort by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1976. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 0             | 6          | 22            | 78         | 22                     | 84         |
| February                            | 0             | 2          | 7             | 30         | 7                      | 32         |
| March                               | 0             | 0          | 4             | 17         | 4                      | 17         |
| April                               | *             | 9          | 0             | 14         | *                      | 23         |
| May                                 | 0             | 0          | 1             | 6          | 1                      | 6          |
| June                                | 0             | 0          | 2             | 7          | 2                      | 7          |
| July                                | 1             | 5          | 77            | 264        | 78                     | 269        |
| August                              | 0             | 0          | 25            | 76         | 25                     | 76         |
| September                           | 0             | 3          | 16            | 33         | 16                     | 36         |
| October                             | 2             | 3          | 11            | 35         | 13                     | 38         |
| November                            | *             | 1          | 6             | 122        | 6                      | 123        |
| December                            | *             | 21         | 1             | 62         | 1                      | 83         |
| Total                               | 3             | 50         | 172           | 744        | 175                    | 794        |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 0             | 0          | 0             | 0          | 0                      | 0          |
| Yellowfin tuna                      | 0             | 25         | 33            | 249        | 33                     | 274        |
| Bigeye tuna                         | 0             | 0          | 0             | 1          | 0                      | 1          |
| Bluefin tuna                        | 0             | 0          | 0             | *          | 0                      | *          |
| Skipjack tuna                       | 9             | 85         | 563           | 2303       | 572                    | 2388       |
| Total tunas                         | 9             | 110        | 596           | 2553       | 605                    | 2663       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Frigate tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Others                              | 0             | *          | 2             | 13         | 2                      | 13         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 28.--Estimated catch and effort by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1977. (From Yong and Wetherall 1980.)

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | 0             | 0          | *             | 32         | *                      | 32         |
| February                            | 0             | 0          | 45            | 167        | 45                     | 167        |
| March                               | 16            | 227        | 10            | 36         | 26                     | 263        |
| April                               | 10            | 73         | 20            | 65         | 30                     | 138        |
| May                                 | *             | 6          | 0             | 2          | *                      | 8          |
| June                                | 0             | 2          | 55            | 172        | 55                     | 174        |
| July                                | 0             | 1          | 52            | 150        | 52                     | 151        |
| August                              | *             | 5          | 25            | 107        | 25                     | 112        |
| September                           | 1             | 2          | 16            | 99         | 17                     | 101        |
| October                             | 0             | 2          | 8             | 70         | 8                      | 72         |
| November                            | 0             | 13         | 11            | 170        | 11                     | 183        |
| December                            | 0             | 2          | 1             | 39         | 1                      | 41         |
| Total                               | 27            | 333        | 243           | 1109       | 270                    | 1442       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 0             | 0          | *             | 5          | *                      | 5          |
| Yellowfin tuna                      | 0             | 13         | 63            | 431        | 63                     | 444        |
| Bigeye tuna                         | 0             | 1          | 1             | 6          | 1                      | 7          |
| Bluefin tuna                        | 0             | 1          | 0             | 8          | 0                      | 9          |
| Skipjack tuna                       | 94            | 2044       | 846           | 2995       | 940                    | 5039       |
| Total tunas                         | 94            | 2059       | 910           | 3445       | 1004                   | 5504       |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Frigate tuna                        | 0             | 0          | 0             | 0          | 0                      | 0          |
| Others                              | 0             | 7          | 15            | 70         | 15                     | 77         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.



Table 29.—Estimated catch and effort by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1978.

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 ml. | Within FCZ | Within 50 ml. | Within FCZ | Within 50 ml.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | *             | 1          | *             | 52         | *                      | 53         |
| February                            | *             | 2          | 9             | 72         | 9                      | 74         |
| March                               | *             | 4          | 4             | 32         | 4                      | 36         |
| April                               | 4             | 77         | 6             | 79         | 10                     | 156        |
| May                                 | 3             | 21         | 5             | 24         | 8                      | 45         |
| June                                | *             | *          | 60            | 252        | 60                     | 252        |
| July                                | *             | *          | 52            | 186        | 52                     | 186        |
| August                              | *             | 6          | 85            | 210        | 85                     | 216        |
| September                           | 2             | 5          | 21            | 75         | 23                     | 80         |
| October                             | *             | *          | 14            | 20         | 14                     | 20         |
| November                            | *             | 2          | 38            | 94         | 38                     | 96         |
| December                            | *             | 1          | 13            | 46         | 13                     | 47         |
| Total                               | 9             | 119        | 307           | 1,142      | 316                    | 1,261      |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | *             | *          | 1             | 10         | 1                      | 10         |
| Yellowfin tuna                      | *             | 11         | 99            | 348        | 99                     | 359        |
| Bigeye tuna                         | *             | 2          | *             | 5          | *                      | 7          |
| Bluefin tuna                        | *             | *          | *             | 1          | *                      | 1          |
| Skipjack tuna                       | 41            | 867        | 1,145         | 4,221      | 1,186                  | 5,088      |
| Total tunas                         | 41            | 880        | 1,245         | 4,585      | 1,286                  | 5,465      |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Frigate tuna                        | *             | *          | *             | *          | *                      | *          |
| Others                              | *             | 2          | 5             | 36         | 5                      | 38         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 30.--Estimated catch and effort by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1979.

|                                     | Guam (A)      |            | CNMI (B)      |            | Areas combined (A + B) |            |
|-------------------------------------|---------------|------------|---------------|------------|------------------------|------------|
|                                     | Within 50 mi. | Within FCZ | Within 50 mi. | Within FCZ | Within 50 mi.          | Within FCZ |
| Monthly nominal effort <sup>1</sup> |               |            |               |            |                        |            |
| January                             | *             | *          | 36            | 86         | 36                     | 86         |
| February                            | 3             | 67         | 204           | 444        | 207                    | 511        |
| March                               | 39            | 238        | 151           | 650        | 190                    | 888        |
| April                               | 3             | 21         | 22            | 76         | 25                     | 97         |
| May                                 | 1             | 7          | 28            | 110        | 29                     | 117        |
| June                                | *             | 8          | 22            | 87         | 22                     | 95         |
| July                                | *             | *          | 61            | 262        | 61                     | 262        |
| August                              | 1             | 3          | 43            | 144        | 44                     | 147        |
| September                           | *             | *          | 59            | 112        | 59                     | 112        |
| October                             | *             | 4          | 32            | 56         | 32                     | 60         |
| November                            | *             | 8          | 16            | 87         | 16                     | 95         |
| December                            | *             | 3          | 10            | 122        | 10                     | 125        |
| Total                               | 47            | 359        | 684           | 2,236      | 731                    | 2,595      |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Albacore                            | 2             | 24         | 13            | 26         | 15                     | 50         |
| Yellowfin tuna                      | *             | 8          | 132           | 436        | 132                    | 444        |
| Bigeye tuna                         | *             | 5          | 2             | 14         | 2                      | 19         |
| Bluefin tuna                        | *             | *          | *             | *          | *                      | *          |
| Skipjack tuna                       | 141           | 1,246      | 2,531         | 8,059      | 2,672                  | 9,305      |
| Total tunas                         | 143           | 1,283      | 2,678         | 8,535      | 2,821                  | 9,818      |
| Annual catch <sup>2</sup>           |               |            |               |            |                        |            |
| Frigate tuna                        | *             | *          | *             | *          | *                      | *          |
| Others                              | *             | 2          | 14            | 64         | 14                     | 66         |

<sup>1</sup>Effort in vessel days, \* = < 1 vessel day.

<sup>2</sup>Catch in metric tons, \* = < 1 mt.

Table 33.--Monthly catch, effort, and catch per unit effort (CPUE) by Japanese baitboats around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), 1970-79.

| Month     | Guam               |                     |                   | CNMI               |                     |                   |
|-----------|--------------------|---------------------|-------------------|--------------------|---------------------|-------------------|
|           | Catch <sup>1</sup> | Effort <sup>2</sup> | CPUE <sup>3</sup> | Catch <sup>1</sup> | Effort <sup>2</sup> | CPUE <sup>3</sup> |
| January   | 115                | 52                  | 2.21              | 560                | 434                 | 1.29              |
| February  | 443                | 126                 | 3.52              | 2,601              | 964                 | 2.70              |
| March     | 3,027              | 586                 | 5.17              | 2,888              | 1,088               | 2.65              |
| April     | 1,250              | 228                 | 5.48              | 1,920              | 567                 | 3.39              |
| May       | 746                | 115                 | 6.49              | 1,236              | 237                 | 5.22              |
| June      | 84                 | 19                  | 4.42              | 7,995              | 1,361               | 5.87              |
| July      | 120                | 44                  | 2.72              | 23,623             | 4,010               | 5.89              |
| August    | 323                | 69                  | 4.68              | 11,615             | 2,603               | 4.41              |
| September | 367                | 113                 | 3.25              | 6,301              | 1,620               | 3.89              |
| October   | 216                | 89                  | 2.43              | 3,317              | 1,008               | 3.29              |
| November  | 320                | 119                 | 2.69              | 3,574              | 1,443               | 2.48              |
| December  | 176                | 89                  | 1.98              | 950                | 657                 | 1.45              |

<sup>1</sup>Catch in metric tons.

<sup>2</sup>Effort in vessel days.

<sup>3</sup>CPUE in metric tons per vessel day.









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THE EARLY LIFE HISTORY OF MAHIMAHI (CORYPHAENA HIPPURUS AND  
C. EUISELIS) AND SKIPJACK TUNA (KATSUWONUS PELAMIS):  
A REPORT ON THE CULTURE AND GROWTH OF LARVAL FISH  
REARED IN THE LABORATORY

Sharon D. Hendrix

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A Final Report Fulfilling Requirements of a  
National Marine Fisheries Service Contract  
(Purchase Order No. 82-ABA-305)

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## PREFACE

This report was prepared under contract (Purchase Order No. 82-ABA-305) by Sharon D. Hendrix, graduate student, University of Hawaii. The contract objectives were to collect and analyze data on the effects of various diets and rearing conditions on growth and survival of mahimahi (Coryphaena hippurus and C. equiselis) and skipjack tuna (Katsuwonus pelamis) larvae reared under laboratory conditions. These data will provide information and insight on the early life histories of these commercially valuable species. The data will also provide a guide for future studies such as those designed to measure the effects of normal environmental fluctuations and pollutants on survival and growth of these fish species' larvae in the wild. Since the report has been prepared under contract, the statements, findings, conclusions, and recommendations herein are those of the contractor and do not necessarily reflect the view of the National Marine Fisheries Service.

Richard W. Brill  
Fishery Biologist

March 4, 1983





The early life history of mahimahi (Coryphaena hippurus and C. equiselis) and skipjack tuna (Katsuwonus pelamis): A report on the culture and growth of larval fish reared in the laboratory.

## INTRODUCTION

Laboratory culture techniques have been developed that enable scientists to obtain information on the early life history of tropical pelagic marine fishes that is not possible to obtain using sea-caught larvae. This type of information is valuable for the understanding of the ecology of tropical pelagic larval fish as well as for the potential aquaculture of these species. This report summarizes studies of the growth, development, behavior, mortality and condition of larval skipjack tuna (Katsuwonus pelamis) and mahimahi (Coryphaena hippurus and C. equiselis) reared in controlled laboratory conditions. The objective of this study was to compare growth and survivorship of mahimahi and skipjack tuna larvae reared in the laboratory under different culture techniques and diets.



## MATERIALS AND METHODS

This work was completed during 1982 at the Kewalo Research Facility of the National Marine Fisheries Service Honolulu Laboratory (KRF). Mahimahi were cultured from March - May and August - October, and skipjack tuna were cultured from June - August when spawning adult skipjack tuna were available. Mahimahi (C. hippurus) eggs were obtained from captive spawning adults held at KRF, the Oceanic Institute (Makapuu Pt.), and the Waikiki Aquarium. Eggs were spawned and fertilized naturally, without hormone or stress inducement. C. equiselis eggs were obtained from naturally spawning adult broodstock maintained at the Waikiki Aquarium. Skipjack tuna eggs were obtained at KRF by stress induced spawning of newly captured adult skipjack tuna (Kaya et al, 1982). Mean egg diameters for skipjack tuna and mahimahi were determined by measuring the diameters of 25 eggs sampled from each spawn. Skipjack tuna eggs were shipped to Kinki University in Japan, and to NMFS-SWFC La Jolla laboratory for coordinated rearing experiments among these three laboratories.

Skipjack tuna eggs were stocked into rearing tanks at a density of 15 eggs/liter, mahimahi eggs at 10 eggs/liter. Rearing tanks were cylindrical black fiberglass tanks with volume maintained at 300 liters (diameter = 1.22 m, water depth = 24 cm). Smaller cylindrical





black fiberglass vessels were used for food selection experiments (volume = 25-30 l, diameter = 40 cm). Fluorescent lamps suspended over the tanks provided illumination of approximately  $6 \times 10^4$  watt/cm at the surface. Rearing tanks were fitted with a 1 cm grid at the bottom that was used for behavioral work as well as density estimates. Rearing tanks were initially filled with 300 liters of UV sterilized or 0.22  $\mu$ m millipore filtered seawater. Volume was maintained at 300 liters by a constant level siphon (Houde, 1972). Daily additions of the diatom Chaetoceros (4-8 liters/day of dense culture) helped to maintain water quality (Mayo, 1973; Houde, 1972; Hassler and Rainville, 1975). Each day, water was siphoned from the tank bottoms to remove dead larvae and prey organisms. Usually, 10-20% of the total tank volume was exchanged each day, by replacing the siphoned water with freshly filtered seawater and algae.

Mahimahi eggs and yolk sac larvae were subjected to moderate aeration, which was decreased upon initiation of feeding behavior. Skipjack tuna eggs and larvae were subjected to gentle or no aeration. Mahimahi were also reared in outdoor conditions. The tanks were exposed to indirect sunlight and water temperatures ranged from 25-29°C. Temperature in the indoor rearing tanks ranged from 21-24°C.



## Larval culture

Mahimahi and skipjack tuna larvae were initially fed laboratory cultures of rotifers (Brachionus plicatilis) and/or harpacticoid copepods (Euterpina acutifrons). These prey organisms were stocked at a density of 5-10 organisms/ml. As larvae grew, they were fed progressively larger prey, such as Artemia salina nauplii (or larger stages of Artemia when required), laboratory cultured harpacticoid copepods (Tigriopus sp.) and mahimahi yolk sac larvae. Large mahimahi larvae (approximately 2-3 cm standard length, > 25 days old) were fed mollies and diced squid. Juvenile mahimahi were transferred to large (2.43 and 7.3 m diameter), outdoor tanks supplied with circulating seawater.

Growth rates were determined by sampling 10 or more larvae periodically, but fewer larvae were sampled as the numbers of larvae in a tank population declined. Standard Length (SL), eye diameter, head depth, yolk sac length and width, and oil globule diameter were measured while larvae were alive, using a calibrated micrometer mounted in a dissecting microscope. Bodies were saved in either 3% buffered formalin or 80% ethanol.

Behavioral observations were made daily if possible, noting



feeding behavior and swimming speed. Swimming speeds were determined by counting the number of 1 cm grid crossings made by a larva over time, and taking the mean of 10-12 observations per day (observation times were >10 seconds in length). During swimming speed observations, the number of feeding strikes made by each larva (successful and unsuccessful) was noted.

#### Food selection

Food selection experiments were conducted on C. equisetis and C. hippurus. Eggs were stocked in small rearing vessels at a density of 15 eggs/liter. Food organisms were distributed to the rearing vessels as follows;

1. Rotifers, (B. plicatilis), 5/ml,
2. Rotifers, 2.5/ml + copepods, (Tigriopus sp.), 2.5/ml,
3. Copepods, (Tigriopus sp.), 5/ml,
4. Starvation.

As a further control, a large 300 liter rearing tank was also used; larvae reared in this tank were given rotifers as food organisms. Food selection was determined by allowing larvae to feed for a 1 hr period (larvae feed visually, so a 1 hr feeding period is equivalent to the first hour of light), and then sampling 20 larvae





for stomach analysis and growth determinations. Bodies were saved in 80% ethanol for future otolith studies. Food Selectivity was determined (Strauss, 1979) and mortality records were kept. Feeding selectivity experiments were conducted daily upon larvae died on day 10, whichever came first. Behavioral observations were made only for larvae reared in the 300 liter tanks, due to difficulty observing larvae in the small vessels.

## RESULTS

### General observations

Skipjack tuna larvae are difficult to culture. However, the 1982 efforts resulted in rearing of skipjack tuna from hatching to metamorphosis (up to day 35) at NMFS La Jolla (S. Kaupp, pers. comm.). Skipjack tuna were successfully cultured for 7 days at KRF and 15 days at Kinki University in Japan (T. Harada, pers. comm.). C. hippurus larvae were successfully reared through metamorphosis to approximately day 191 when the fish were lost due to rupture of their holding tank). Only one attempt was made to rear C. equiselis, the larvae survived through day 8.

Both skipjack tuna and mahimahi eggs are spherical and transparent. Skipjack tuna eggs ranged from 0.889 to 0.982 mm in



diameter, while C. hippurus eggs were 1.52-1.86 mm in diameter, and C. equiselis eggs were approximately 1.4 mm in diameter. At hatching, skipjack tuna larvae averaged 2.9-3.0 mm in length with a yolk sac ranging from 0.78 to 1.03 mm in length and 0.52 to 0.66 mm in width. C. hippurus larvae at hatching averaged 4.3 to 5.4 mm in length with a yolk sac ranging from 1.54 to 1.85 mm in length and 0.39 to 0.47 mm in width and an oil globule of 0.31 to 0.34 mm in diameter. 8-67% of skipjack tuna and mahimahi larvae were observed to have been deformed at first feeding (usually jaw and head abnormalities), presumably due to poor egg quality.

At hatching, skipjack tuna larvae were nearly transparent and had very little pigmentation through day 12. By comparison, mahimahi were transparent at hatching but became darkly pigmented by day 2. Mahimahi yolk sac larvae (up until day 2), were much like skipjack tuna larvae in that they were nearly transparent and tended to float near the surface in a head down position, essentially motionless, except for occasional bursts of swimming.

At day 2, mahimahi larvae tended to orient near the bottom of the tanks, with very few larvae remaining in the upper half of the water column. Larvae that settled to the tank bottom tended to become fouled by bacteria, hence tank water needed to be agitated in order to prevent mahimahi larvae from remaining on the bottom.



Generally, mahimahi larvae had pigmented eyes and functional jaws and stomachs by day 3.

At day 3, mahimahi larvae were oriented near the surface and swam horizontally, usually feeding. Skipjack tuna larvae tended to remain bouyant throughout the yolk sac period and into first feeding. Eyes became pigmented, and stomachs and jaws functional by day 3.

Mahimahi larvae exhibited marked variation in pigmentation on day 4, coloration varied from light yellow to dark brown. The lightly colored larvae demonstrated a tendency to feed more actively and appeared more robust than did the dark larvae. In adult mahimahi, stressed fish become very darkly pigmented, especially at capture and near death. This coloration response may also apply to mahimahi larvae. Larvae of both skipjack tuna (S. Kaupp, pers. comm.) and mahimahi metamorphosed by day 35 and were piscivorous (able to feed on other fish larvae) by day 25 (S. Kaupp, pers. comm.). Cannibalism was not observed in either larval skipjack tuna or mahimahi within a brood.

#### Growth

Selected growth data are summarized for skipjack tuna larvae in table 1 and for both species of mahimahi in table 2. Skipjack tuna





larvae reared at KRF did not exhibit significant growth. However, growth was significant for larvae reared at NMFS La Jolla laboratory, with one larva reaching a length of 39.5 mm on day 35 (S. Kaupp, pers. comm.). Skipjack tuna larvae reared at La Jolla grew in spurts, larvae grew rapidly with each addition of larger prey types (ie. rotifers, copepods, yolk sac larvae) and grew better when the dinoflagellate Tahitian Isochrasis was added to the rearing vessel (S. Kaupp, pers. comm.). At day 34, the last surviving cultured skipjack tuna larva ingested 40 to 50 10-12 mm halibut larvae, representing a substantial energy intake (S. Kaupp, pers. comm.). The larva died due to unforeseen circumstances.

The effect of temperature on growth of mahimahi (C. hippurus) is seen in figure 1. Growth at 26.2°C and 22.8°C was comparable up until day 12, when there was a rapid acceleration in growth of larvae reared at 26.2°C (fig. 1). Corresponding trends in growth with temperature are seen for head depth and eye diameter (figs. 2 and 3). Mahimahi larvae reared at 26.2°C grew at nearly the same rate as mahimahi reared at 27°C (Hassler and Rainville, 1975; Palko et al, 1982). Growth of head depth and eye diameter varied linearly with length (figs. 4 and 5). Linear equations were fit to data describing growth of mahimahi reared at 26.2°C as seen in fig. 4.

Results obtained from food selection experiments did not



demonstrate any effect of diet on growth. Cultures of E. acutifrons were not available for these selection experiments, therefore Tigriopus sp. was used as a prey organism with rotifers. Tigriopus is a large harpacticoid copepod with demersal nauplii, and thus, Tigriopus are not good prey for first feeding larvae. Indeed, no larvae reared on Tigriopus survived beyond day 6. Therefore, growth data are taken only from feeding experiments using rotifers as prey. The length-age plot for the first ten days of growth of mahimahi larvae (C. hippurus) was nonlinear (fig. 6).

The growth of mahimahi was modeled by two generalized equations which describe significant events in early larval growth. The first equation describes growth from hatching through yolk absorption and first feeding. During this period, larvae approached an asymptotic length between days 2 and 6 (fig.6). This asymptotic function may best describe growth in length, but conceivably growth described by other parameters such as dry weight or calories may not demonstrate the same trend. After significant mortalities on days 6-7, surviving larvae initiated exponential growth. The generalized equations of this model are:

$$L_t = \begin{cases} \lambda(1 - \theta e^{-\gamma t}) & ; \quad 0 \leq t \leq \tau \\ \lambda(1 - \theta e^{-\gamma \tau}) \left(\frac{t}{\tau}\right)^\beta & ; \quad t > \tau \end{cases}$$

where  $L_t$  = length at age  $t$ ;

$\lambda$  = asymptotic length approached by first feeding larvae  
before exponential growth commences;



$\lambda(1 - \theta)$  = length at  $t = 0$ ;

$\tau$  = transition between growth stages;

$\gamma$  = rate of growth when  $0 < t < \tau$ ;

$\beta$  = rate of growth when  $t > \tau$ .

Estimated parameters are given in table 3 for growth data presented in fig. 6. This is a general growth model describing larval C. hippurus but should be applicable to early growth of other species of larval fish (Hunter, 1976). Again, larval growth was linear with respect to head depth, eye diameter and length (figs. 7 and 8).

Differences in growth due to starvation are not apparent until day 5 (table 4). By day 6, starved larvae have significantly smaller eye diameters and are shorter than fed larvae, but head depths are not significantly different (table 4).

#### Mortality

Skipjack tuna larvae reared at KRF tended to have very heavy mortality with most larvae dying or dead by day 4. A similar mortality trend was seen in starvation experiments on larval pacific mackerel (Hunter and Kimbrell, 1980), and mahimahi reared at KRF, where starved larvae began to die on day 4 and were all dead by day 7. Both species of mahimahi raised at KRF generally exhibited less





than 5% mortality per day from hatching through day 5. On days 6 and 7, larvae suffered higher mortality rates of between 7-63% per day (fig. 9). Few of the skipjack tuna larvae successfully initiated feeding. Less than 50% of the larvae sampled on day 3 had any food present in their stomachs. Even so, there is evidence that larvae selected Euterpina nauplii over rotifers when given a choice, and larvae generally ingested larger proportions of copepod nauplii than were available as prey in the environment (fig 10). Sea-caught skipjack tuna larvae from the Hawaii region usually have only larvaceans or the cyclopoid copepod Corycaeus sp. in their stomachs, perhaps indicating a strong selection for these prey types (Uotani et al, 1981; and pers. obs.). We suspected that egg size may influence the length of larvae at hatching and the amount of yolk reserves available to the larvae. Smaller eggs could result in an energetic deficiency because they have a smaller amount of available yolk. A comparison was made of larvae reared from 2 spawns with different mean ova diameters (table 5). No significant effect of ova diameter was found on larvae from hatching through first feeding (table 5).

Initial feeding experiments on C. hippurus indicate a tendency for larvae to select for Euterpina copepods from first feeding through day 7 when presented a diet of both rotifers and copepods (fig. 11, table 6). Rotifer fed larvae did not have a tendency to



select to either gravid or nongravid rotifers (fig. 12, table 7). Tigriopus-fed mahimahi larvae (both C. equisetis and C. hippurus), tended to ingest only Tigriopus fecal pellets. As mentioned earlier, Tigriopus are not adequate prey for first feeding larvae due to inaccessibility of small naupliar stages. Fecal pellets are approximately  $60 \times 110 \mu\text{m}$  in size and are probably easily ingested by mahimahi larvae.

No trends were seen in swimming speeds of mahimahi larvae from first feeding to day 10, however increases in feeding strike frequency were shown (fig. 13). Mahimahi and skipjack tuna larvae demonstrated typical larval scombrid feeding behavior (Hunter, 1980; Hassler and Rainville, 1975). A larva would sight a prey organism, draw its tail back so that its body was in a tight "s" or "j" curve, and then strike and ingest the prey. Observations of mahimahi indicated that a larva would not always strike a prey item, even if the larva coiled its body into an "s" curve. This behavior is noted as "abandoned strikes" in fig. 13. Ten day old larvae had a smaller proportion of abandoned strikes than 7 day old larvae (fig. 13). When mahimahi were large enough to feed on other yolk sac larvae, these prey were usually engulfed with little or no handling time; ingestion was quick and efficient.

Mahimahi larvae started "rafting" behavior around day 20. This



involved orienting and maintaining a position under or relative to stationary items such as airline tubing. This type of behavior is frequently seen in adult mahimahi (Hunter and Mitchell, 1967).

#### DISCUSSION AND RECOMMENDATION

This years efforts to rear skipjack tuna were promising, with larvae cultured through metamorphosis. Even so, skipjack tuna are difficult to rear and exhibit very low survivorship (Mayo, 1973; Uyenagi et al, 1974; Inoue et al, 1974; Houde and Richards, 1969). The results obtained indicate an overall poor egg quality, especially since mortality was so high during yolk sac stages and deformities were so common. Poor maternal investment due to stress induced spawning could possibly have caused the deformities and high mortalities. However skipjack tuna can be reared to metamorphosis successfully, which suggests other causative factors.

Diet is very critical to larval survival. Results from rearing skipjack tuna in La Jolla indicate that larval growth may have been reduced by the inability of the larvae to consume sufficient energy to meet the demands of rapid development (S. Kaupp, pers. comm.). For future research on skipjack tuna, I recommend the following:

1. Rear skipjack tuna from naturally spawned eggs obtained from





plankton tows to see if stress induced ovulation effects egg quality and to test rearing techniques.

2. Continue work on diet to obtain optimal prey types, focus on energy demands of larvae and caloric content of prey. Rear skipjack tuna larvae on wild plankton, especially larvaceans and Corycaeus sp. (these prey species are found in the diets of sea-caught larvae).. Continue work on stomach analysis of sea-caught skipjack tuna larvae to determine other optimal foods.

Both skipjack tuna and mahimahi demonstrate rapid growth rates, and require large quantities of food for growth and maintenance (Mayo, 1973). Mahimahi appear to be a hardier species than skipjack tuna. Pigmentation occurs very early in mahimahi development, suggesting that mahimahi larvae may live near the surface while skipjack have been found at depths of 20 meters (Sund et al, 1981). The observation that mahimahi larvae will ingest fecal pellets is important in several aspects. It is unknown if they ingest fecal pellets in their natural environment. If mahimahi larvae will ingest inanimate objects such as fecal pellets, it raises the question: can mahimahi be aquacultured on artificial diets from first feeding?

Abandonment of feeding strikes is another ecologically interesting phenomena. Why should a mahimahi larva abandon a prey once it is sighted and strike position is attained? Here is an



example of potential energy waste, since the larva abandons or loses its prey and must search for another. Perhaps the best explanation for this phenomena is that the prey item swims out of the effective visual range of the mahimahi larva after the larva has achieved strike position. Another possible explanation is that the larva may actually abandon a prey item because the prey is unsuitable due to incorrect size or type.

Mahimahi represent an excellent species to use as a model for growth and condition of larval fishes. The obvious effect of diet and food selection on growth should be seen in the growth function (or second equation) of the 5 parameter model presented in this report. The rate of acceleration of growth after day 6 should reflect the condition of the larvae, healthier larvae should grow faster. This potential variation in growth rate may be reflected in otolith increment width, which would be useful as a criterion for larval fish condition in the sea (Hunter, 1976; Methot, 1979).

I recommend continued work on larval mahimahi (especially *C. hippurus*) with the following studies:

1. Continue food selection studies and attempt to determine if a criterion for larval condition (otolith increment width) can be established.



2. Use mahimahi as a model for improving culture techniques applicable to skipjack tuna larvae. Optimize culture techniques, experiment with temperature effects, effects of hormones such as thyroxine, and effects of various prey types (including effects of different algal species as the primary step in the food chain) on larval growth and survival. If possible, conduct stomach analysis on sea-caught mahimahi larvae.

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Table 1: Summary of growth and survivorship from 1982 rearing experiments on skipjack tuna larvae (Katsuwonus pelamis).  
 Number of larvae sampled, mean length ( $\bar{x}$ ) and standard deviation (SD) in mm are given with information on spawn date, tank identification, feeding conditions and mean temperature  $\pm$  1 SD ( $^{\circ}\text{C}$ )

| Age (days) | 16 June 82 |           |       | 20 June 82 |           |       | 28 June 82 |           |       | 6 July 82 |           |       | 31 July 82 |           |              |
|------------|------------|-----------|-------|------------|-----------|-------|------------|-----------|-------|-----------|-----------|-------|------------|-----------|--------------|
|            | Tank A     | Rotifers  |       | Tank B     | Euterpina |       | Tank B     | Euterpina |       | Tank C    | Mix*      |       | TankC      | Mix       | La Jolla mix |
| 0          | n          | $\bar{x}$ | SD    | n          | $\bar{x}$ | SD    | n          | $\bar{x}$ | SD    | n         | $\bar{x}$ | SD    | n          | $\bar{x}$ | SD           |
| 1          | 12         | 3.34      | 0.194 | 12         | 2.83      | 0.256 | 12         | 3.22      | 0.195 | 12        | 2.94      | 0.230 | 12         | 2.87      | 0.249        |
| 2          | 12         | 3.34      | 0.194 | 12         | 3.65      | 0.081 | 12         | 3.38      | 0.153 | 12        | 2.94      | 0.230 | 12         | 2.87      | 0.249        |
| 3          |            |           |       | 12         | 3.592     | 0.155 | 12         | 3.59      | 0.153 | 12        | 3.54      | 0.135 | 12         | 3.68      | 0.127        |
| 4          | 12         | 3.30      | 0.129 |            |           |       |            |           |       | 10        | 3.69      | 0.076 | 12         | 4.03      | 0.227        |
| 5          | 12         | 3.36      | 0.184 | 1          | 3.35      |       |            |           |       | 4         | 3.73      | 0.087 |            |           |              |
| 6          | 2          | 3.55      | 0.141 |            |           |       |            |           |       | 2         | 4.20      | 0.283 |            |           |              |
| 7          |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 8          |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 9          |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 10         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 11         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 12         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 13         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 14         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 15         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 16         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 17         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 18         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| //         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |
| 35         |            |           |       |            |           |       |            |           |       |           |           |       |            |           |              |

\*Mix=rotifers + Euterpina  
 or rotifers + Tigriopus

1 4.80  
 1 8.20  
 4 8.75  
 //  
 1 39.50





Table 2: Summary of growth and survivorship from selected 1982 rearing experiments on mahimahi larvae (Coryphaena hippurus and C. equiselis).  
 Number of larvae sampled, mean length ( $\bar{x}$ ) and standard deviation (SD) in mm are given with information on spawn date, tank identification, feeding conditions and mean temperature  $\pm$  1 SD ( $^{\circ}\text{C}$ )

| Age (days) | 4 May 82                           |           | 6 May 82                           |           | 15 October 82                      |           | 15 October 82                      |           | 17 October 82                      |           |
|------------|------------------------------------|-----------|------------------------------------|-----------|------------------------------------|-----------|------------------------------------|-----------|------------------------------------|-----------|
|            | Tank B                             |           | Tank D                             |           | Tank C                             |           | Pot D                              |           | Pot I                              |           |
|            | Mix *                              |           | Mix                                |           | Rotifers                           |           | starved                            |           | Rotifers                           |           |
|            | 22.82 $^{\circ}\text{C} \pm 0.387$ |           | 26.26 $^{\circ}\text{C} \pm 0.427$ |           | 22.89 $^{\circ}\text{C} \pm 1.043$ |           | 21.95 $^{\circ}\text{C} \pm 0.554$ |           | 22.78 $^{\circ}\text{C} \pm 0.172$ |           |
|            | <u>C. hippurus</u>                 |           | <u>C. hippurus</u>                 |           | <u>C. hippurus</u>                 |           | <u>C. hippurus</u>                 |           | <u>C. hippurus</u>                 |           |
|            | n                                  | $\bar{x}$ | n                                  | $\bar{x}$ | n                                  | $\bar{x}$ | n                                  | $\bar{x}$ | n                                  | $\bar{x}$ |
| 0          | 15                                 | 4.87      |                                    |           | 20                                 | 4.96      |                                    |           |                                    |           |
| 1          | 15                                 | 5.37      |                                    |           | 20                                 | 5.27      |                                    |           |                                    |           |
| 2          | 15                                 | 5.40      |                                    |           | 20                                 | 5.34      |                                    |           |                                    |           |
| 3          | 10                                 | 5.56      | 12                                 | 5.30      | 20                                 | 5.39      | 20                                 | 5.15      | 20                                 | 5.33      |
| 4          |                                    |           |                                    |           | 20                                 | 5.39      | 20                                 | 5.34      | 20                                 | 5.42      |
| 5          | 12                                 | 5.50      | 10                                 | 5.62      | 20                                 | 5.39      | 20                                 | 5.29      | 20                                 | 5.56      |
| 6          |                                    |           |                                    |           | 20                                 | 5.39      | 20                                 | 5.36      | 20                                 | 5.52      |
| 7          | 10                                 | 5.75      | 5                                  | 6.13      | 20                                 | 5.54      | 20                                 | 4.80      | 20                                 | 5.57      |
| 8          |                                    |           |                                    |           | 20                                 | 5.84      | 5                                  |           | 11                                 | 5.59      |
| 9          | 5                                  | 6.38      | 3                                  | 6.50      | 20                                 | 5.98      |                                    |           |                                    | 0.178     |
| 10         |                                    | 0.177     | 3                                  | 6.40      | 20                                 | 6.26      |                                    |           |                                    |           |
| 11         | 1                                  | 6.90      | 1                                  | 7.25      | 20                                 | 6.70      |                                    |           |                                    |           |
| 12         | 1                                  | 6.90      |                                    |           | 14                                 | 6.99      |                                    |           |                                    |           |
| 13         |                                    |           | 3                                  | 7.88      |                                    | 0.556     |                                    |           |                                    |           |
| 14         |                                    |           |                                    |           |                                    |           |                                    |           |                                    |           |
| 15         | 2                                  | 7.95      | 2                                  | 8.68      |                                    |           |                                    |           |                                    |           |
| 16         |                                    |           | 1                                  | 8.10      |                                    |           |                                    |           |                                    |           |
| 17         |                                    |           | 1                                  | 11.2      |                                    |           |                                    |           |                                    |           |
| 18         | 1                                  | 11.2      | 2                                  | 15.3      |                                    |           |                                    |           |                                    |           |
| 19         |                                    | 0.888     |                                    | 1.69      |                                    |           |                                    |           |                                    |           |
| 20         | 3                                  | 8.8       |                                    |           |                                    |           |                                    |           |                                    |           |
| 21         | 1                                  | 10.2      |                                    |           |                                    |           |                                    |           |                                    |           |
| 22         | 2                                  | 10.6      |                                    |           |                                    |           |                                    |           |                                    |           |
| 23         |                                    |           |                                    |           |                                    |           |                                    |           |                                    |           |
| 24         | 1                                  | 7.0       |                                    |           |                                    |           |                                    |           |                                    |           |
| 25         | 2                                  | 12.75     |                                    |           |                                    |           |                                    |           |                                    |           |
| 26         |                                    |           |                                    |           |                                    |           |                                    |           |                                    |           |
| 27         |                                    |           |                                    |           |                                    |           |                                    |           |                                    |           |
| 28         |                                    |           |                                    |           |                                    |           |                                    |           |                                    |           |

\*Mix=rotifers + Euterpina or Tigriopus



Table 3: Estimated parameters for the model describing the growth of mahimahi (C. hippurus) larvae spawned on 15 October 1982.

| PARAMETER | ESTIMATE | ASYMPTOTIC<br>STD. ERROR | ASYMPTOTIC 95%<br>CONFIDENCE INTERVAL |         |
|-----------|----------|--------------------------|---------------------------------------|---------|
|           |          |                          | LOWER                                 | UPPER   |
| THETA     | 0.26169  | 0.07891                  | 0.06859                               | 0.45480 |
| LAMBDA    | 5.39764  | 0.02551                  | 5.33520                               | 5.46006 |
| TAU       | 5.51097  | 0.17353                  | 5.08634                               | 5.93560 |
| GAMMA     | 1.16619  | 0.30249                  | 0.42604                               | 1.90636 |
| BETA      | 0.31923  | 0.02667                  | 0.25398                               | 0.38449 |



Table 4: Comparison of starved vs fed mahimahi larvae (C. hippurus) from 15 Oct. 82 spawn.

| AGE<br>(DAY) | PARAMETER<br>(mm) | STARVED<br>$\bar{x} \pm 1 \text{ SD}$ | FED<br>$\bar{x} \pm 1 \text{ SD}$ | F STAT |
|--------------|-------------------|---------------------------------------|-----------------------------------|--------|
| Day 4        | Length            | 5.34 $\pm$ 0.0614                     | 5.40 $\pm$ 0.0743                 | 2.483  |
|              | Eye<br>diameter   | 0.349 $\pm$ 0.012                     | 0.342 $\pm$ 0.009                 | 4.333  |
|              | Head<br>depth     | 0.780 $\pm$ 0.068                     | 0.754 $\pm$ 0.058                 | 1.681  |
|              |                   |                                       |                                   |        |
| Day 5        | Length            | 5.285 $\pm$ 0.113                     | 5.48 $\pm$ 0.121                  | 27.917 |
|              | Eye<br>diameter   | 0.354 $\pm$ 0.009                     | 0.357 $\pm$ 0.009                 | 0.978  |
|              | Head<br>depth     | 0.806 $\pm$ 0.029                     | 0.790 $\pm$ 0.048                 | 1.652  |
|              |                   |                                       |                                   |        |
| Day 6        | Length            | 5.355 $\pm$ 0.087                     | 5.55 $\pm$ 0.115                  | 37.609 |
|              | Eye<br>diameter   | 0.355 $\pm$ 0.009                     | 0.367 $\pm$ 0.012                 | 13.286 |
|              | Head<br>depth     | 0.865 $\pm$ 0.064                     | 0.869 $\pm$ 0.055                 | 0.0460 |
|              |                   |                                       |                                   |        |



Table 5: Comparison of skipjack tuna larvae reared from eggs obtained from different females spawned on 28 June 1982.  
(note tank B and C have eggs obtained from the same female).

| PARAMETER            | TANK A             | TANK B             | TANK C             |
|----------------------|--------------------|--------------------|--------------------|
|                      | $\bar{x} \pm 1$ SD | $\bar{x} \pm 1$ SD | $\bar{x} \pm 1$ SD |
| Ova diameter (mm)    | 0.94 $\pm$ 0.006   | 0.981 $\pm$ 0.015  | 0.981 $\pm$ 0.015  |
| Length at hatch (mm) |                    |                    |                    |
| (n=12)               | 3.25 $\pm$ 0.085   | 3.221 $\pm$ 0.195  | 3.30 $\pm$ 0.182   |
| Length at day 3 (mm) |                    |                    |                    |
| (n=12)*              | 3.617 $\pm$ 0.109  | 3.595 $\pm$ 0.153  | 3.535 $\pm$ 0.134  |
| Swim speed           |                    |                    |                    |
| cm/sec               | 0.3468             | 0.3921             | 0.4324             |
| body Length/sec      | 0.9589             | 1.090              | 1.226              |
| #feeding strikes     |                    |                    |                    |
| per min              | 0.1177             | 0.1069             | 0.1324             |
| %larvae with food    | 25%                | 0%                 | 25%                |
| %larvae without      |                    |                    |                    |
| food                 | 75%                | 100%               | 75%                |
| # Euterpina nauplii  |                    |                    |                    |
| ingested             | 5                  | 0                  | 3                  |
| Temperature (°C)     | 23.6 $\pm$ 0.363   | 23.45 $\pm$ 0.42   | 23.6 $\pm$ 0.35    |

\* data listed below this entry pertain to day 3 larvae





Table 6: Results of initial feeding experiments conducted on mahimahi larvae (C. hippurus) spawned on 6 May, 1982.

| LENGTH<br>INTERVAL<br>(mm) | % without<br>food | % with<br>food | TOTAL #<br>LARVAE | RATION             |                 |                              |                                |                    |
|----------------------------|-------------------|----------------|-------------------|--------------------|-----------------|------------------------------|--------------------------------|--------------------|
|                            |                   |                |                   | #Brachi<br>loricas | #Brachi<br>eggs | <u>Euterpina</u><br>#nauplii | <u>acutifrons</u><br>#copepods | #gravid<br>females |
| 5.1-5.5                    | 56                | 44             | 16                | 8                  | 8               | 63                           | 108                            | 1                  |
| 5.6-6.0                    | 10                | 100            | 5                 | 2                  | 1               | 38                           | 112                            | 1                  |
| 6.1-6.5                    | 0                 | 100            | 7                 | 8                  | 0               | 140                          | 158                            | 8                  |
| 6.6-7.0                    | 0                 | 100            | 4                 | 4                  | 0               | 134                          | 92                             | 2                  |
| 7.1-7.5                    | 0                 | 100            | 1                 | 1                  | 1               | 27                           | 5                              | 1                  |



Table 7: Results of feeding experiments conducted on mahimahi larvae  
(C. hippurus) spawned on 15 October, 1982.

| LENGTH<br>INTERVAL<br>(mm) | %without<br>food | %with<br>food | TOTAL #<br>LARVAE | RATION             |                 |                       |                           |
|----------------------------|------------------|---------------|-------------------|--------------------|-----------------|-----------------------|---------------------------|
|                            |                  |               |                   | #Brachi<br>loricas | #Brachi<br>eggs | #Tigriopus<br>nauplii | #Tigriopus<br>copepodites |
| 5.1-5.5                    | 84.85            | 15.15         | 66                | 96                 | 43              | 0                     | 0                         |
| 5.6-6.0                    | 41.67            | 58.33         | 48                | 283                | 64              | 0                     | 0                         |
| 6.1-6.5                    | 20.0             | 80.0          | 30                | 253                | 26              | 2                     | 0                         |
| 6.6-7.0                    | 0                | 100           | 12                | 271                | 9               | 4                     | 0                         |
| 7.1-7.5                    | 0                | 100           | 4                 | 215                | 11              | 0                     | 0                         |



Figure 1: Growth of mahimahi (*C. hippurus*) reared at 2 different temperatures; 26.2°C  $\pm$  0.91°C (+) and 22.8°C  $\pm$  0.29°C (•). Points represent individual larvae.

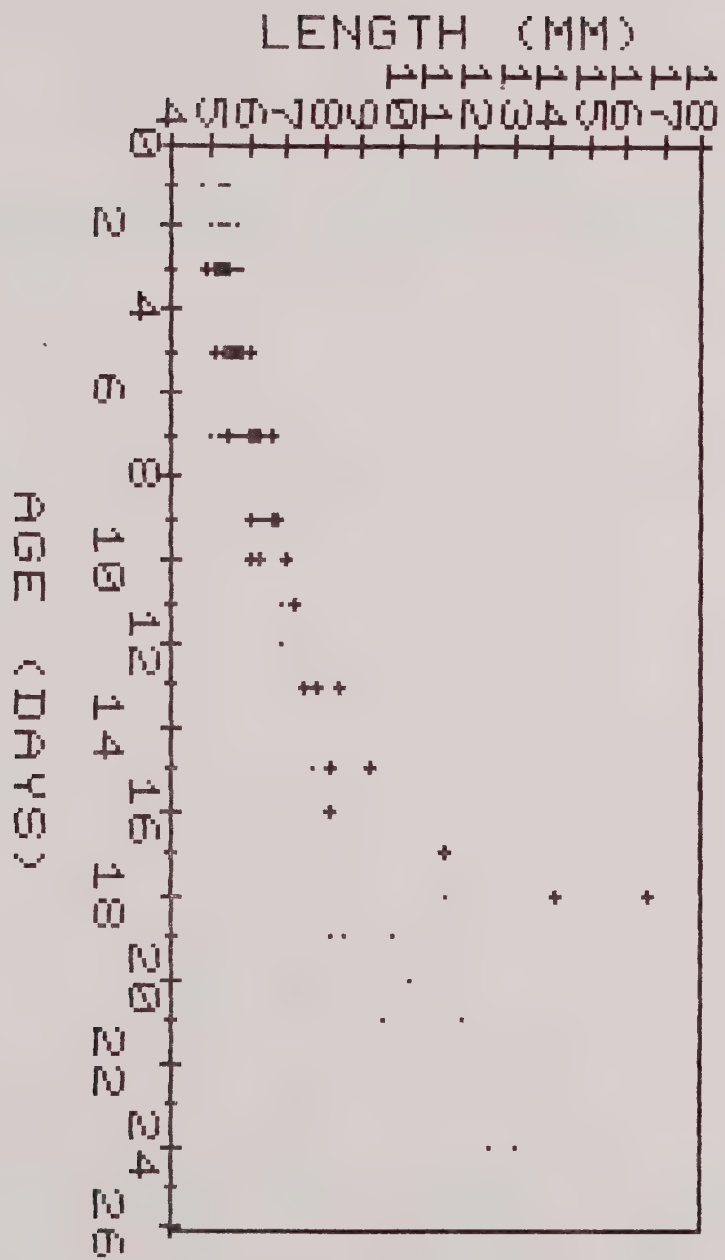






Figure 2: Growth of head depth (▣) and eye diameter (+) for mahimahi larvae (C. hippurus) reared at  $26.2 \pm 0.91^{\circ}\text{C}$ . Points represent individual larvae.

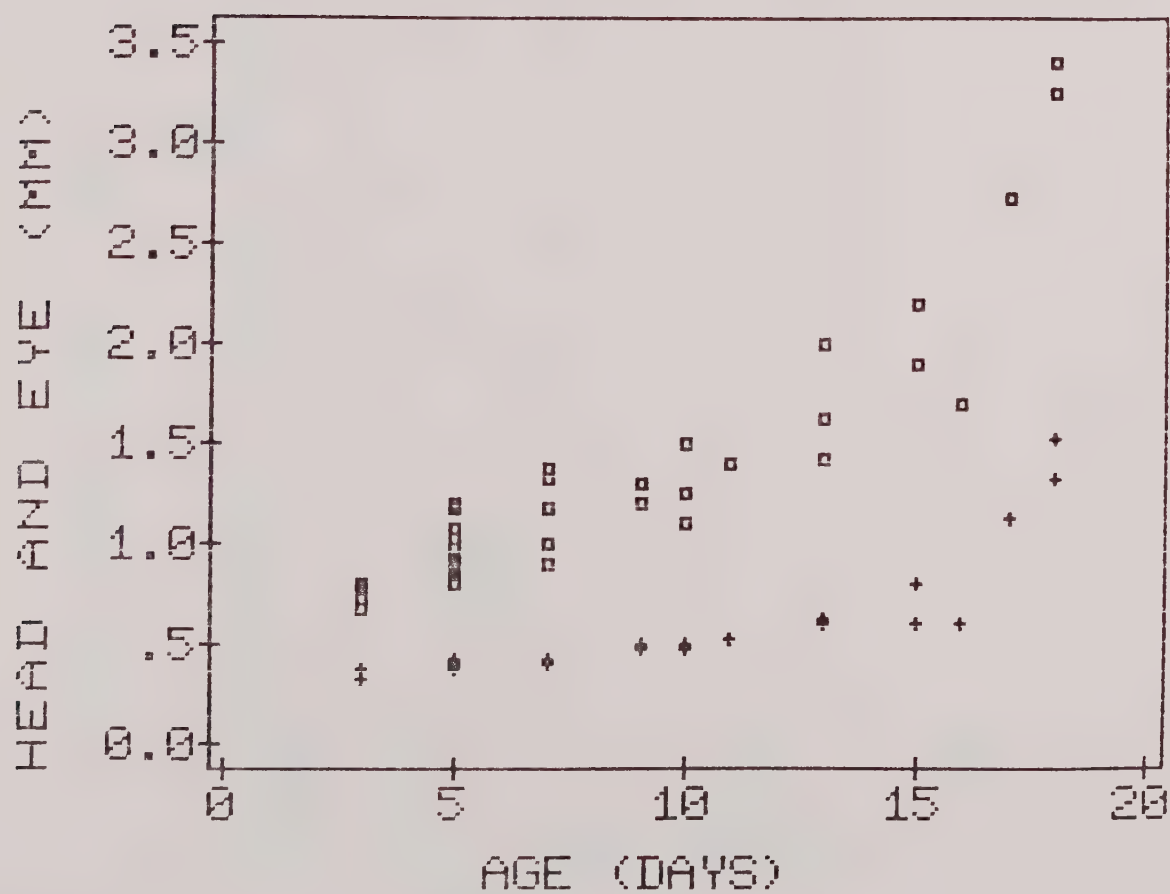




Figure 3: Growth of head depth ( $\square$ ) and eye diameter (+) for mahimahi larvae (*C. hippurus*) reared at  $22.8 \pm 0.29^\circ\text{C}$ . Points represent individual larvae.

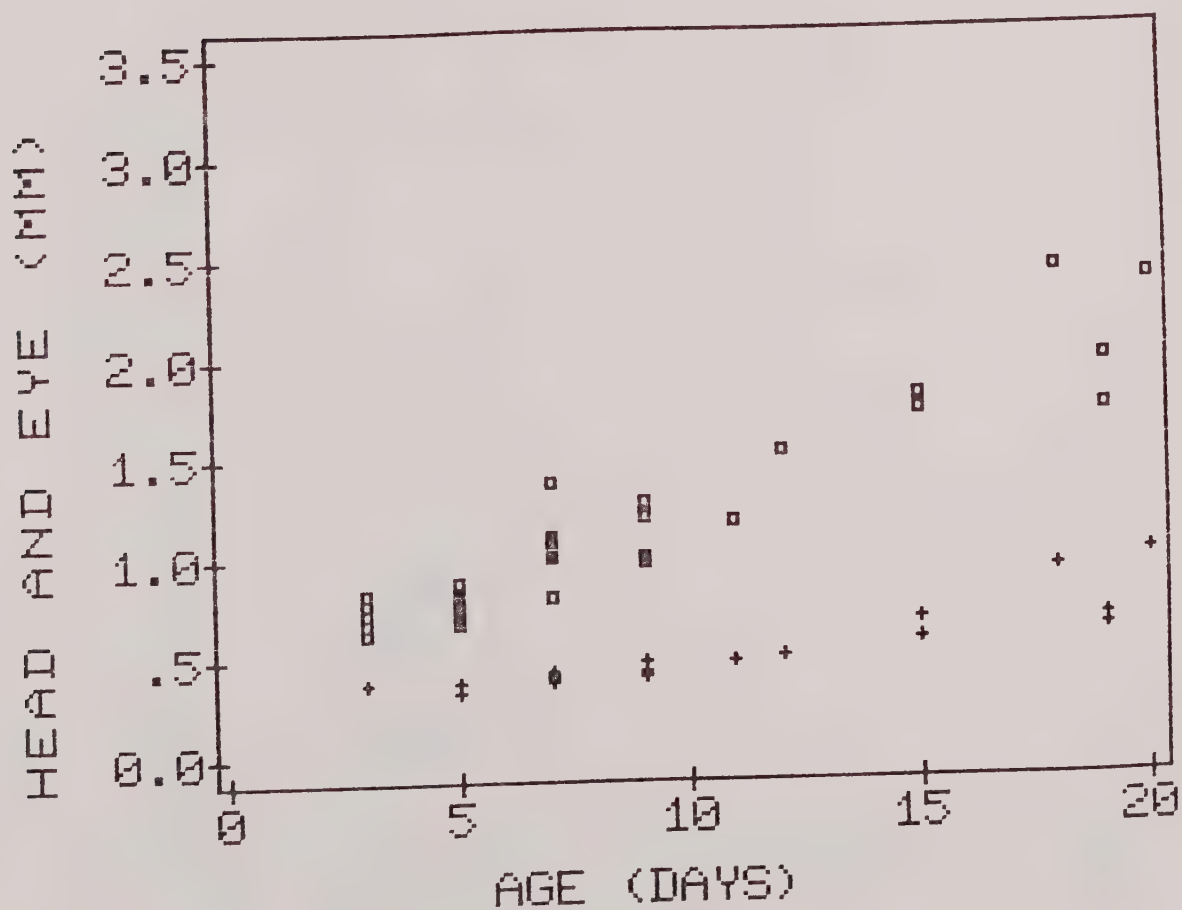




Figure 4: Linear growth of mahimahi larvae (*C. hippurus*) reared at  $26.2 \pm 0.91^\circ\text{C}$ .  
 Head depth ( $\square$ ) and eye diameter (+) vs Length.  
 Points represent individual larvae

$$\text{Head depth} = -1.0664 + 0.354 \text{ Length}, r^2 = 0.92$$

$$\text{Eye diameter} = -0.1441 + 0.0949 \text{ Length}, r^2 = 0.91$$

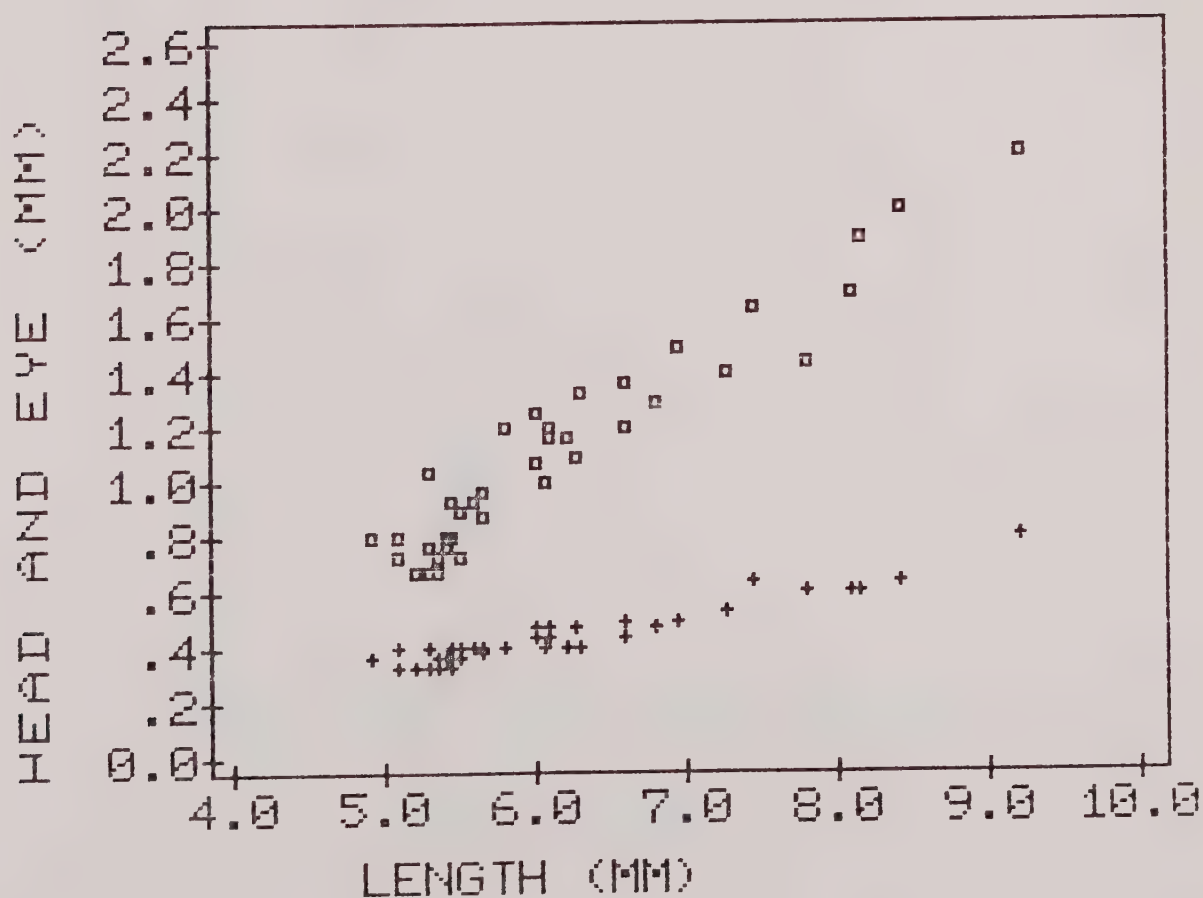




Figure 5: Linear growth of mahimahi larvae (*C. hippurus*) reared at  $22.8 \pm 0.29^\circ\text{C}$ .  
 Head depth ( $\square$ ) and eye diameter (+) vs length.  
 Points represent individual larvae.

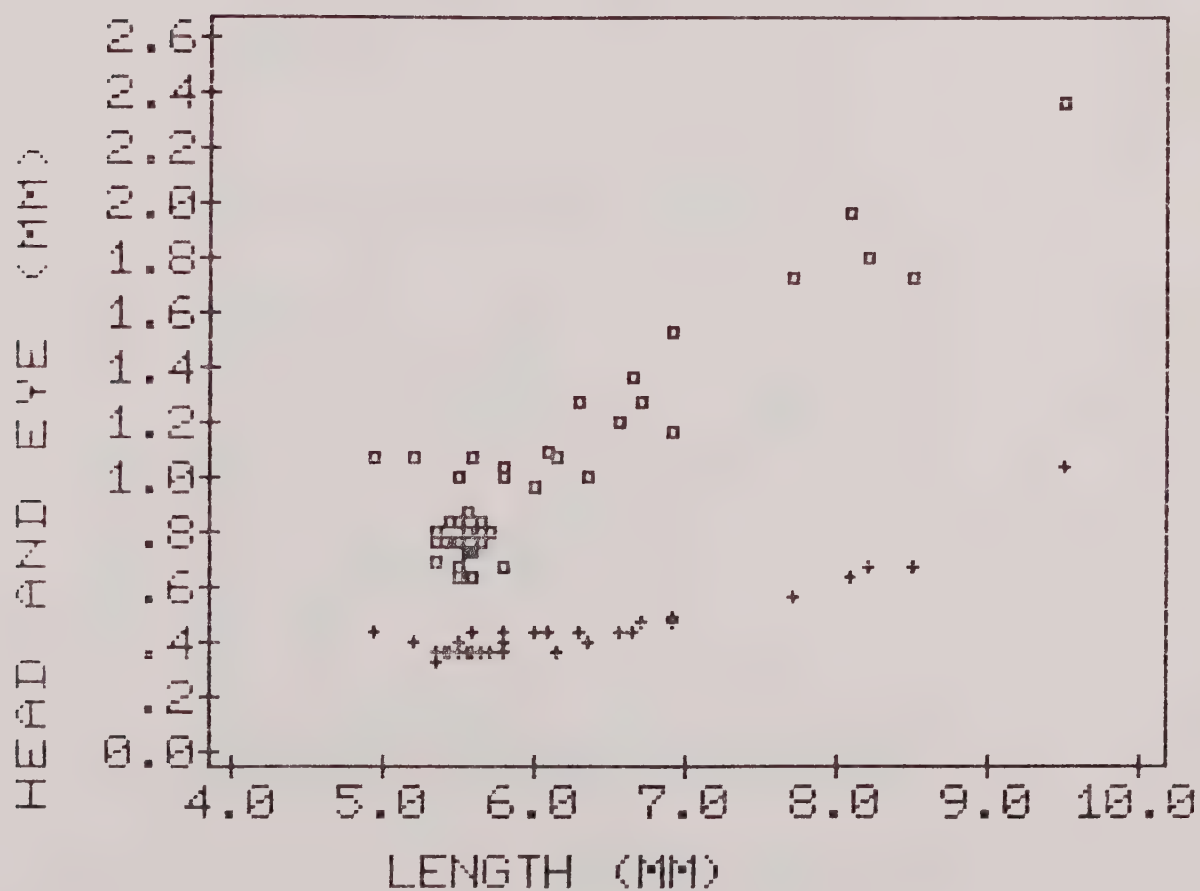






Figure 6: Growth of mahimahi larvae (C. hippurus). Plot is of mean length  $\pm$  1 SD of the mean. (data obtained from food selection experiments conducted on 15 Oct. 82 spawn).

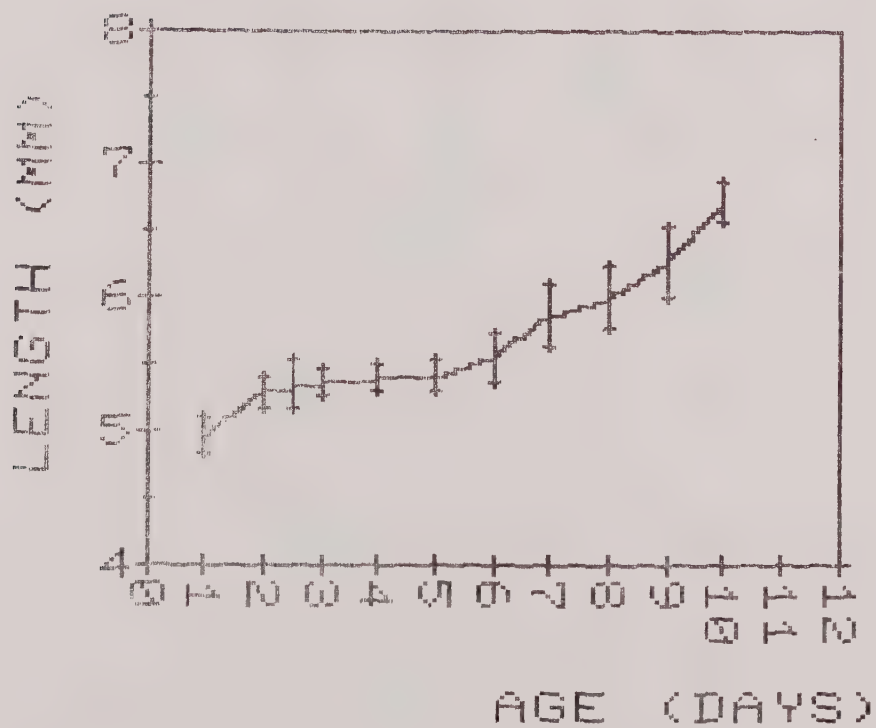




Figure 7: Growth of mahimahi larvae (*C. hippurus*). Plot is of mean head depth (■) and eye diameter (•)  $\pm 1$  SD of the mean. (data obtained from food selection experiments conducted on 15 Oct. spawn).

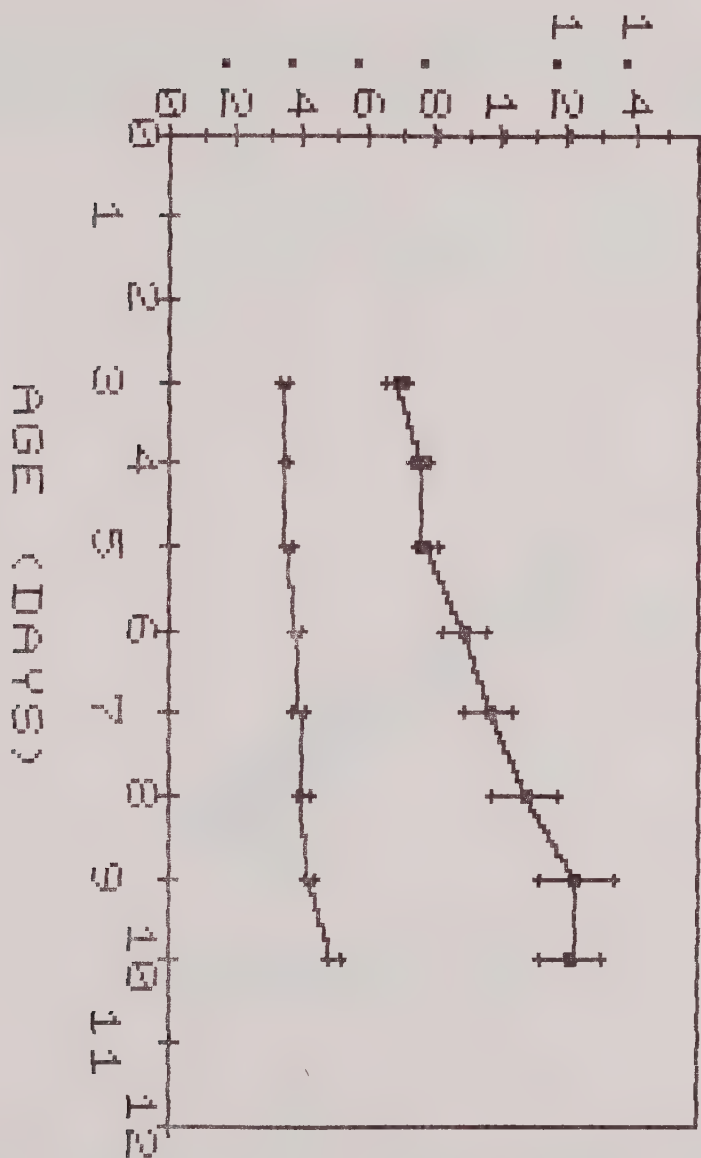




Figure 8: Growth of mahimahi larvae (*C. hippurus*). Head depth ( $\square$ ) and eye diameter (+) vs Length. Points represent individual larvae. (data obtained from food selection experiments conducted on 15 Oct. spawn).

$$\text{Head depth} = -1.2265 + 0.3739 \text{ Length}, r^2 = 0.83$$

$$\text{Eye diameter} = -0.01994 + 0.06952 \text{ Length}, r^2 = 0.84$$

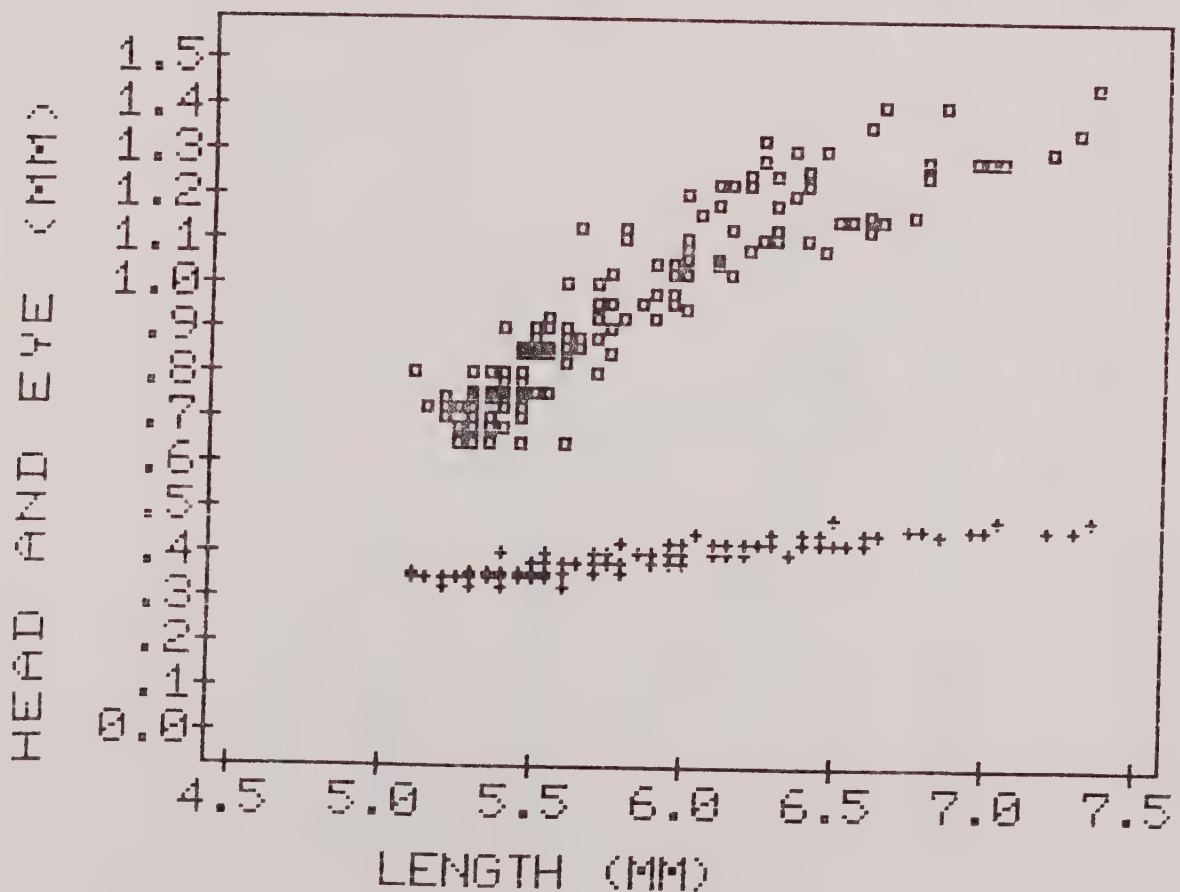




Figure 9: Survivorship of mahimahi larvae (*C. hippurus*) reared under various conditions. (data obtained from 15 Oct. spawn).

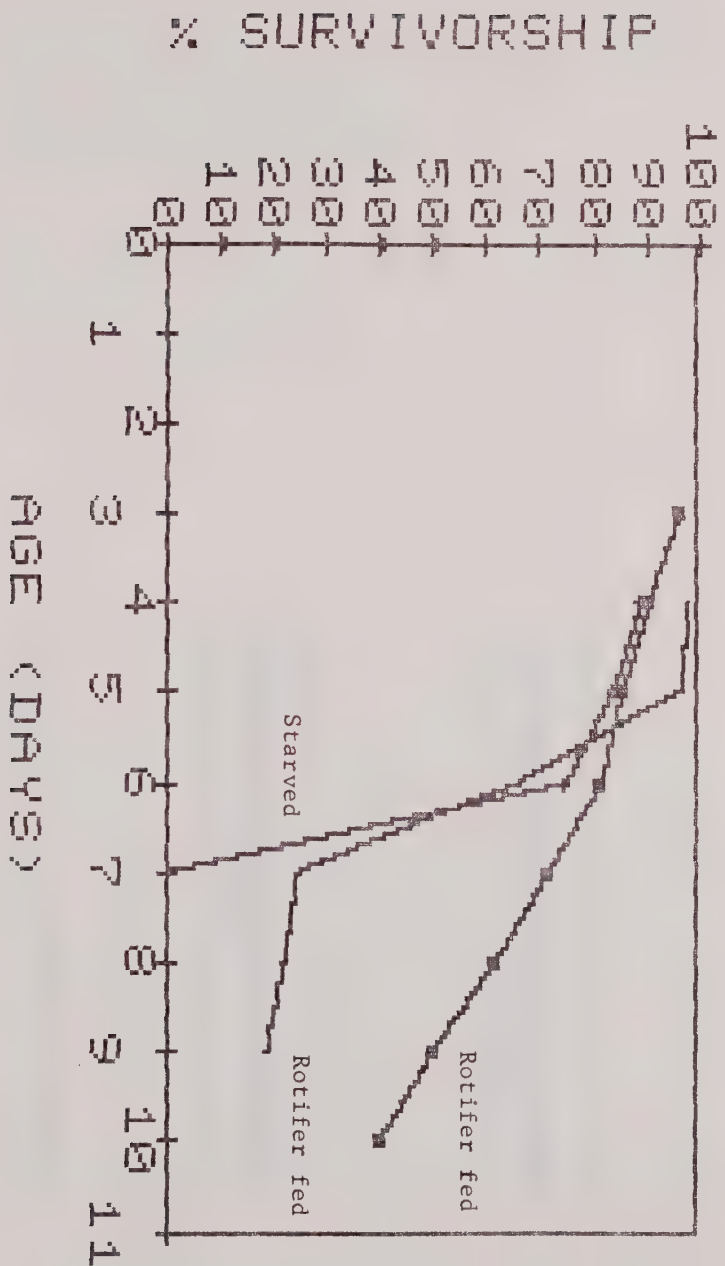






Figure 10: Food selection by skipjack tuna larvae on day 3. Comparison of the proportion of available food (P) to the ration (R).  
 Clear bars=nongravid rotifers,  
 shaded bars=gravid rotifers,  
 slashed bars=Euterpina nauplii,  
 stippled bars=Euterpina copepodites.

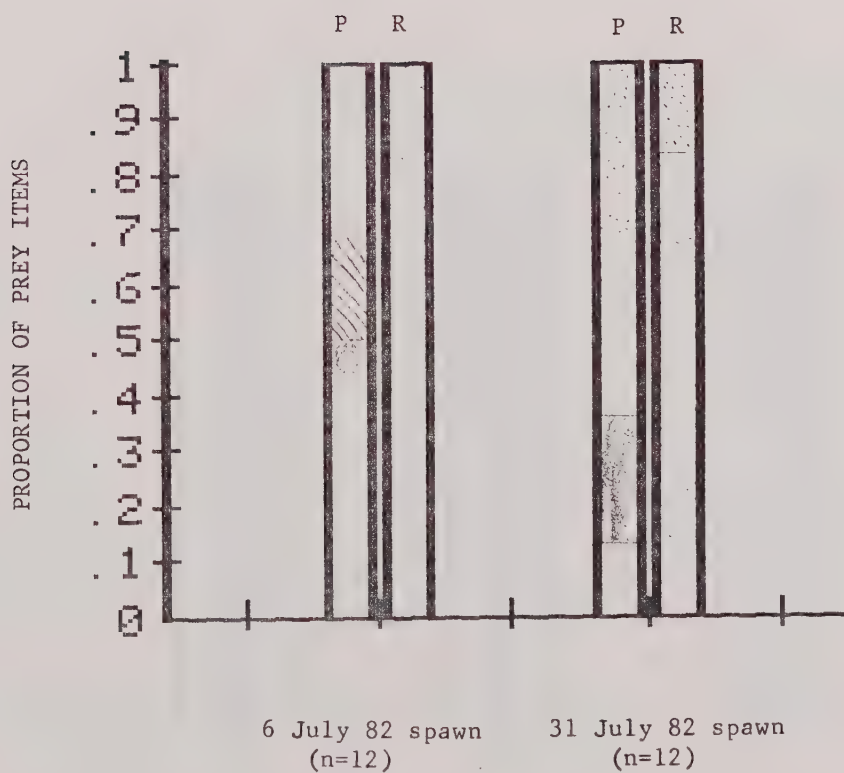




Figure 11: Food selection by mahimahi larvae (*C. hippurus*, 16 May 82 spawn).  
 Comparison of the proportion of available food (P) to the ration (R).  
 Shaded bars=*Euterpina* copepods,  
 Clear bars=*Euterpina* nauplii ,  
 Slashed bars=rotifers.

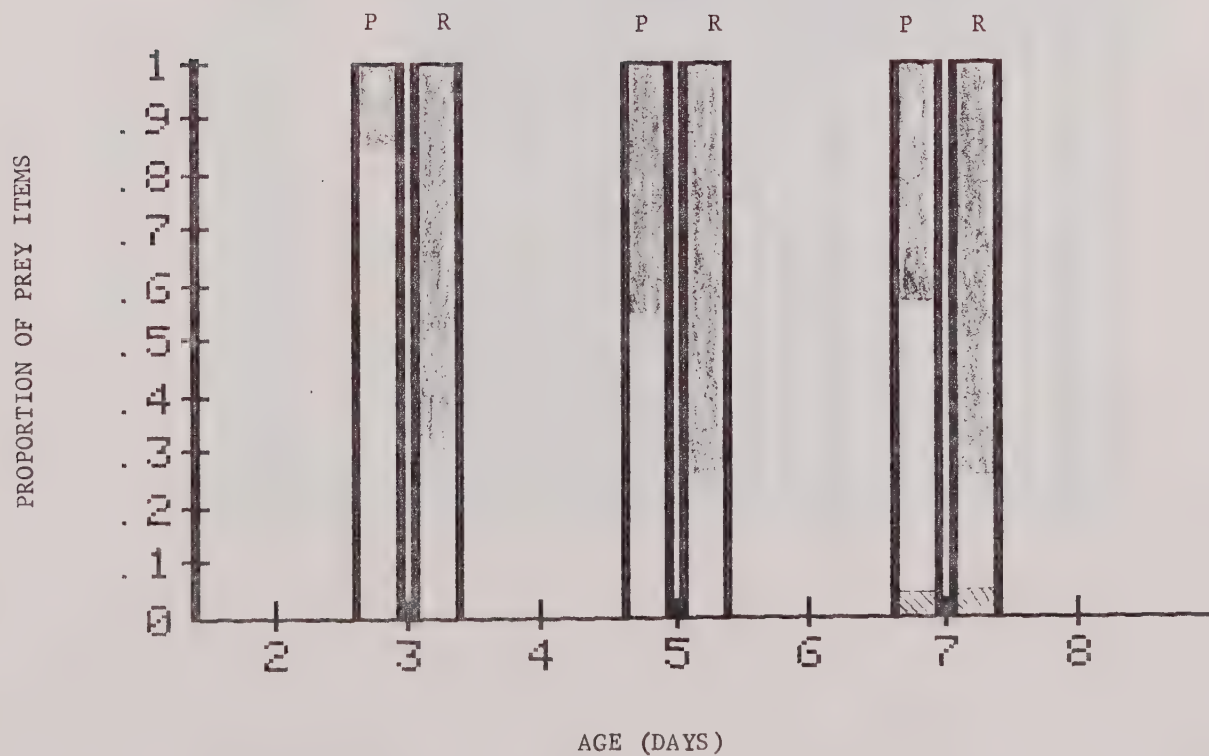


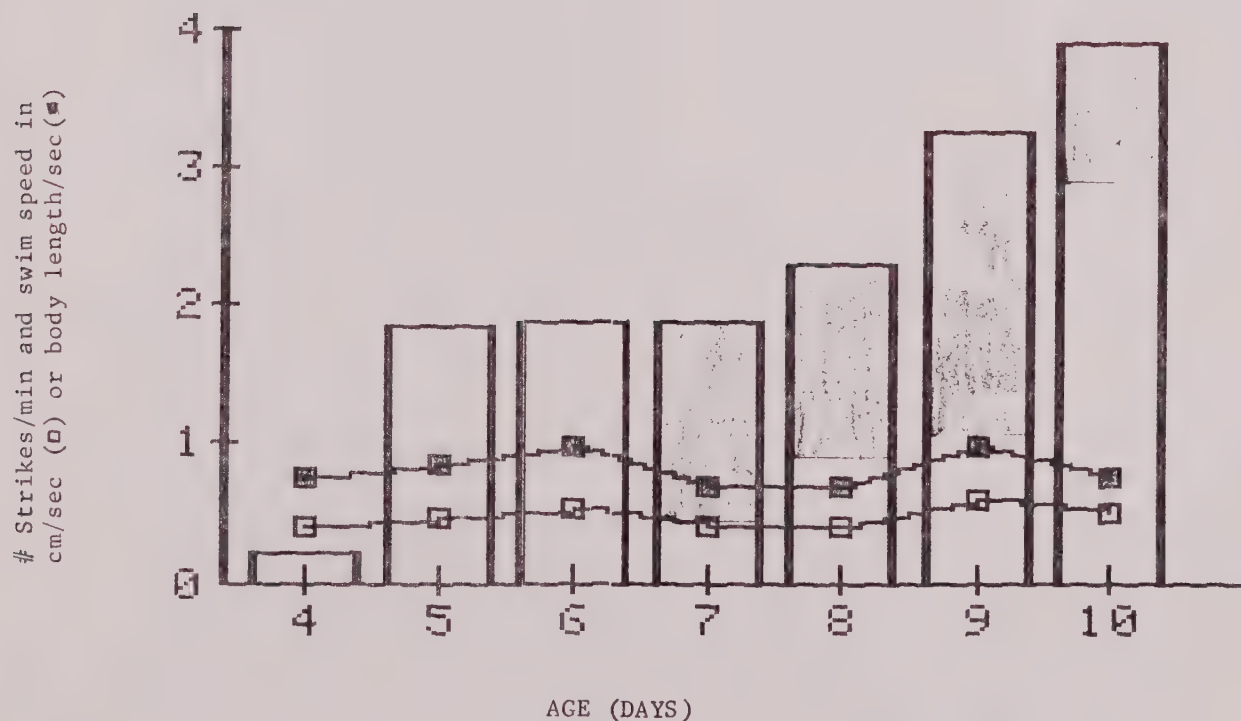


Figure 12: Food selection by mahimahi larvae (C. hippurus, 15 Oct. 82 spawn).  
 Comparison of the proportion of available food (P) to the ration (R).  
 Shaded bars=gravid rotifers,  
 clear bars=nongravid rotifers.





Figure 13: Feeding and swimming behavior for mahimahi larvae (*C. hippurus*).  
Mean swim speeds are given in cm/sec (□) and body lengths/sec (■).  
Bars represent feeding strike behavior;  
Shaded bars=abandoned strikes, clear bars=successful strikes  
(note: no data available on abandoned strikes for days 4-6).  
(data obtained from 15 Oct. spawn).













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A STATISTICAL SAMPLING GUIDE TO INSPECT DOCKSIDE LANDINGS  
FOR ADHERENCE TO THE REGULATIONS IN THE  
FISHERY MANAGEMENT PLAN FOR SPINY LOBSTERS

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The Fishery Management Plan (FMP) for spiny lobster imposes restrictions on the size and reproductive condition of spiny lobster, Panulirus marginatus, which can be taken from the Northwestern Hawaiian Islands (NWHI). These regulations, as given in the Federal Register 47(126), are:

"§681.21. Size restrictions.

- "(a) Whole lobsters. Only spiny lobsters with a carapace length of 7.7 cm or greater may be retained.
- "(b) Lobster tails. If the carapace length cannot be determined, only lobsters with tails at least 5.0 cm wide may be retained, except for an allowance of up to 15 percent of the catch, by number, which may have tail widths between 4.5 and 4.9 cm.

"§681.22. Reproductive condition restrictions.

A female spiny lobster of any size may not be retained if it is carrying eggs externally. Eggs may not be removed from female spiny lobsters."

As one activity to enforce these regulations, the National Marine Fisheries Service (NMFS), Southwest Region, will conduct dockside inspection of the catches from vessels landing lobsters taken in the NWHI. The purpose of this report is to present statistical sampling guidelines which will allow an enforcement agent to inspect a sample of a boat's catch and make a probabilistic statement about whether or not the catch conforms to, or is in violation of, the size and reproductive conditions imposed by the FMP. If the sample inspected indicates a high probability that the catch conforms to the regulations, then typically the catch would be landed without further inspection. If the sample inspected indicates a high probability that the catch includes a significant number of lobsters in violation of the regulations, then all the lobsters may be inspected for positive confirmation.

To develop the sampling guidelines, it is assumed that the sample of lobsters inspected is representative of the catch. From this assumption, it follows that the sampling theory can be developed based on a binomial distribution. It is further assumed that the proportions of the lobsters in the catch with an attribute about which an inference is being made does not exceed 0.25, and that the sample drawn does not exceed one-tenth of the catch. These assumptions insure that the Poisson distribution will be a very close approximation of the binomial distribution. The theory and tables for the sampling guidelines presented here are based on Burstein (1971).

Lobsters are presently landed either as live whole lobsters or are tailed at sea, and landed as frozen tails packaged in blocks. A separate sampling plan will be presented for each of these products.



Case 1. Inspection of live whole lobsters. The regulations in the FMP require that if the whole lobster is landed, its carapace length must equal or exceed 7.7 cm and that it does not carry eggs. The enforcement agent would use Table 1 to determine the size (n) of the random sample to be inspected, once values for parameters B and P have been selected. The value B determines the risk (probability) that a catch, which contains a proportion P or more of lobsters in violation of the regulation, is not detected. For example, if the agent wants to be sure that there is only a 1 in 20 chance that a catch with more than 1% of the lobsters in violation of the regulations on size and reproductive condition will escape detection, the value of B selected will be  $1/20 = 0.05$  and  $P = 0.01$ . From these values of B and P, Table 1 gives a sample size (n) of 299 lobsters to be inspected. If, in this random sample, a violation was found, then obviously the catch is in violation of the regulations. However, if in this sample of 299 lobsters there are no violations, then it can be stated that there is only 1 chance in 20 ( $B = 0.05$ ) that the catch has more than 1% of the lobsters in violation of the regulations. If it is felt that stricter controls are required, for example, that there is only 1 chance in 100 ( $B = 0.01$ ) that a catch with more than 0.5% ( $P = 0.005$ ) of the lobsters in violation will not be detected, then it will be necessary to inspect a random sample of 918 lobsters.

Table 1.--Sample sizes (n) for selected values of P and B  
(from Burstein 1971).

| n   | P     | B     |
|-----|-------|-------|
| 118 | 0.025 | 0.05  |
| 299 | 0.01  | 0.05  |
| 598 | 0.005 | 0.05  |
| 146 | 0.025 | 0.025 |
| 367 | 0.01  | 0.025 |
| 736 | 0.005 | 0.025 |
| 180 | 0.025 | 0.01  |
| 458 | 0.01  | 0.01  |
| 918 | 0.005 | 0.01  |

Case 2. Inspection of frozen tails. The regulation requires that if frozen tails are landed, none carry eggs, none have widths of the first tail segment  $<4.5$  cm, and no more than 15% of the catch have tail widths between  $<5.0$  and  $\geq 4.5$  cm (the 15% tolerance). This case is more complicated than Case 1 due to the 15% tolerance condition. First, suppose we are just interested in sampling to insure that the 15% tolerance condition is not violated. An enforcement agent would select values of  $P_2$ , A, and B (Table 2) which then determine the sample size (n) to be inspected and the acceptance value C to test whether or not the 15% tolerance condition has been violated. The value B is the risk of not detecting a





violation in the 15% tolerance level when, in fact, the proportion of the catch with tail widths between  $<5.0$  and  $\geq 4.5$  cm is  $\geq P_2$ . The parameter A is the probability that based on the sample inspected, it is erroneously concluded that the 15% tolerance is exceeded, when in fact, it is not. For example, based on values  $B = 0.01$ ,  $A = 0.05$ , and  $P_2 = 0.25$ , a random sample of 208 tails would be measured; the acceptance value is 37 (Table 2). If fewer than 38 tail widths in the sample were  $<5.0$  and  $\geq 4.5$  cm, then the catch would be accepted as conforming to the 15% tolerance condition and it can be concluded that there is only 1 chance in 100 ( $B = 0.01$ ) that the proportion of the catch with tail width  $<5.0$  and  $\geq 4.5$  cm would exceed 0.25 ( $P_2 = 0.25$ ). If, however, more than 37 tails in the sample of 208 have widths  $<5.0$  and  $\geq 4.5$  cm, then it can be concluded it is likely that the 15% tolerance level is exceeded in the catch since given the 15% tolerance, there is only 1 chance in 20 ( $A = 0.05$ ) that more than 37 tail widths would be  $<5.0$  and  $\geq 4.5$  cm, in a random sample of 208. In this latter case, all the tails would probably be measured for positive confirmation. Up to now, only the 15% tolerance level has been considered. When the sample size n determined from Table 2 is inspected, the agent will also check for any tails containing eggs and any tails with widths  $<4.5$  cm.

Table 2.--Sample sizes (n) and acceptance values (C) for selected values of  $P_2$ , A, and B (from Burstein 1971).

| n   | C   | $P_2$ | A    | B     |
|-----|-----|-------|------|-------|
| 208 | 37  | 0.25  | 0.05 | 0.01  |
| 170 | 31  | 0.25  | 0.05 | 0.025 |
| 143 | 27  | 0.25  | 0.05 | 0.05  |
| 781 | 130 | 0.20  | 0.05 | 0.01  |
| 659 | 111 | 0.20  | 0.05 | 0.05  |
| 527 | 90  | 0.20  | 0.05 | 0.05  |

If either of these attributes is found, the catch is in violation of the regulations. If, on the other hand, there are no tails with eggs, no tails have widths  $<4.5$  cm, and the number of tail widths  $<5.0$  and  $\geq 4.5$  cm does not exceed the acceptance level (C) in the sample, then the catch would be accepted as conforming to the regulations of the FMP. The probability of making a mistake and accepting this catch, when in fact, one or more of these conditions are violated is  $P_3$  where:

$$P_3 = 1 - (1 - B_1) (1 - B_2)$$

where  $B_2$  is the value of B from Table 2 and  $B_1$  is the risk (B) from Table 1 for the value of n which is closest to, but does not exceed, the sample size inspected. For example, if a random sample of 208 lobster tails were inspected and fewer than 38 had widths  $<5.0$  and  $\geq 4.5$  cm, and no tails were below 4.5 cm and none had eggs, then the catch would be accepted as



conforming to the size and reproductive regulations of the FMP. The risk of an error, and the proportion of tails with widths  $<5.0$  and  $\geq 4.5$  cm exceeds  $P_2 = 0.25$  and the proportion of tails which either contain eggs and are  $<4.5$  cm in the catch exceeds  $P = 0.025$ , can be determined by:

$$P_3 = 1 - (1 - 0.01) (1 - 0.01) = 0.02 \quad .$$

For this calculation of  $P_3$ , the value of  $B_2$  is 0.01 from Table 2 based on  $n = 208$ , and the largest  $n$  in Table 1 not exceeding 208 is 180, which corresponds to  $P = 0.025$  and  $B_1 = 0.01$ . Table 3 presents some values of  $P_3$  for values of  $n$  from Table 2.

A practical consideration in sampling frozen tails is that a vessel may roughly sort the tails and package them in blocks at sea. In this situation, to take a random sample of size,  $n$ , from the vessel's catch, it will be necessary to select  $n$  packaged blocks at random and measure one tail selected at random from each block. The vessels landing frozen tails typically land about 6,000 pieces, so under our assumptions, the sample size inspected should not exceed one-tenth of the catch or about 600 pieces.

Table 3.--Values of  $P_3$  computed for values of  $n$ ,  $C$ ,  $P_2$ , and  $B_2$  from Table 2 and values of  $P$  and  $B_1$  from Table 1.

| $n$ | $C$ | $P$   | $B_1$ | $P_2$ | $B_2$ | $P_3$ |
|-----|-----|-------|-------|-------|-------|-------|
| 208 | 37  | 0.025 | 0.01  | 0.25  | 0.01  | 0.02  |
| 170 | 31  | 0.025 | 0.025 | 0.25  | 0.025 | 0.05  |
| 143 | 27  | 0.025 | 0.05  | 0.25  | 0.05  | 0.10  |
| 781 | 130 | 0.005 | 0.025 | 0.20  | 0.01  | 0.03  |
| 659 | 111 | 0.005 | 0.05  | 0.20  | 0.05  | 0.10  |
| 527 | 90  | 0.01  | 0.01  | 0.20  | 0.05  | 0.06  |

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THE 1976-78 STUDIES OF THE  
KAILUA-KONA, HAWAII, BILLFISH FISHERY  
PART II  
CHARTER BOAT OPERATORS COMPONENT

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## INTRODUCTION

This report is the second of three presenting the major findings of a series of surveys undertaken in 1976-78 on the billfish fisheries in Kailua-Kona, Hawaii, and contains information on charter boats and their operators based in Kailua-Kona. The previous report presented information on commercial and recreational fishing, and the final report will cover charter boat patrons. The surveys were conducted by Research Associates, Inc. under contract to the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service (NMFS), NOAA. This report is a condensed and edited version of the relevant portions of the contract reports submitted by Research Associates. It complements ongoing research on charter boat fishing in Hawaii being conducted by NMFS and the University of Hawaii, College of Tropical Agriculture. The original reports are available at the Honolulu Laboratory.

## SURVEY RESULTS

### Sampling

Because the number of charter boat operators was relatively small, an attempt was made to interview all operators in the entire fleet. Vessels operating in Kona at the time of the survey (December 1976) were identified through a compilation of membership lists from the two charter boat operators associations in Kailua-Kona. These associations were also able to provide the names of independent boats operating in the area.

At the time of the survey, 29 charter boats were operating at Honokohau (Kailua-Kona) and Keauhou (Kona) harbors. Twenty-five operators cooperated with the survey. The questionnaire is appended to this report.

A personal interview approach was selected to gather the most complete and accurate information from the charter boat operators as was done for the operators of commercial and recreational boats. This method offered the opportunity for interviewers to develop rapport with respondents and reassure them about the goals of the study and the confidentiality of the information gathered. Research Associates' supervisory personnel conducted all interviews with the charter boat operators.

### Description of the Fleet

1. The average charter boat length was 38 ft; only two vessels were under 30 ft, and four over 45 ft. Average horsepower was 355.
2. The average vessel was priced at \$63,000 and the estimated current (1976) value was \$77,000.

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<sup>1</sup>National Marine Fisheries Service. 1982. The 1976-78 studies of the Kailua-Kona, Hawaii, billfish fishery, Part I, commercial/recreational component. Southwest Fish. Cent. Admin. Rep. H-82-3, 22 p. + Appendix. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.



3. Five operators entered the business during late 1975 and in 1976. Four operators were in business over 10 years. The average was 5 years in the Kailua-Kona charter boat fishery.

4. Fifty-two percent (13 vessels) of the operators were both owners and skippers of their vessel; 32% (8 vessels) were skippers of vessels owned by others; and 16% (4 vessels) were owners who employed skippers.

5. Fifty-two percent were independent operators and 48% belonged to a charter boat association.

The following tables provide more information on the composition of the charter boat fleet.

Table 1.--Length of vessel.

| Response                                   | Percent |
|--------------------------------------------|---------|
| Less than 30 ft                            | 8       |
| 30-34 ft                                   | 16      |
| 35-39 ft                                   | 36      |
| 40-44 ft                                   | 24      |
| 45 ft or longer                            | 16      |
| Average length:                            | 38 ft   |
| N = 25                                     |         |
| Question: What is the length of your boat? |         |

Table 2.--Horsepower.

| Response                                           | Percent |
|----------------------------------------------------|---------|
| Less than 200 hp                                   | 16      |
| 200-300 hp                                         | 36      |
| 300-400 hp                                         | 8       |
| 400-500 hp                                         | 24      |
| More than 500 hp                                   | 16      |
| Average horsepower of boat:                        | 355     |
| BASE: Total charter boat operators                 | (25)    |
| Question: What is the horsepower of your engine/s? |         |



Table 3.--Cost of vessel.

| Cost of boat        | Percent |
|---------------------|---------|
| Less than \$25,000  | 8       |
| \$25,000-\$39,999   | 20      |
| \$40,000-\$59,999   | 32      |
| \$60,000-\$79,999   | 20      |
| \$80,000-\$99,999   | 4       |
| \$100,000-\$199,999 | 12      |
| \$200,000 or more   | 4       |

Average cost of boat: \$63,080

BASE: Total charter boat operators (25)

Question: What was the cost of the boat when it was purchased?

Table 4.--Estimated price of vessel.

| Value of boat       | Percent |
|---------------------|---------|
| \$25,000-\$39,999   | 16      |
| \$40,000-\$59,999   | 28      |
| \$60,000-\$79,999   | 16      |
| \$80,000-\$99,999   | 8       |
| \$100,000-\$199,999 | 24      |
| \$200,000 or more   | 8       |

Average value of boat: \$77,400

BASE: Total charter boat operators (25)

Question: What would you say is the value of the boat today?

Table 5.--Duration of operation.

| Response           | Percent |
|--------------------|---------|
| 1 year or less     | 20      |
| 2 years            | 24      |
| 3 years            | 16      |
| 4-6 years          | 20      |
| 7-10 years         | 4       |
| More than 10 years | 16      |

Average years in operation: 5

BASE: Total charter boat operators (25)

Question: For how many years has your boat been in operation in Kona as a charter vessel?





Table 6.--Ownership/operation.

| Response          | Percent |
|-------------------|---------|
| Owner and skipper | 52      |
| Skipper only      | 32      |
| Owner only        | 16      |

BASE: Total charter boat operators (25)

Question: Are you the owner of the boat, the skipper of the boat, or both?

Table 7.--Association membership.

| Response             | Percent |
|----------------------|---------|
| Independent operator | 52      |
| Association member   | 48      |

BASE: Total charter boat operators (25)

Question: Are you a member of a charter operators' association, or are you an independent operator?

#### Personal Characteristics

1. All of the charter boat owners and operators were male. Their average age was 41 years.

2. Over half said they were dependent upon the charter operation for their sole source of income. The remainder received 47% of their income from the charter boat business. Vessel earnings are presented in the following section.

3. The average annual earnings of boat skippers (excluding owners) was \$8,750 which includes wages, tips, share of fish, etc.

4. Three quarters of the charter boats employed two persons full time.

The following tables provide more information on the charter boat operators.



Table 8.--Age of owners.

| Response   | Percent |
|------------|---------|
| 18-24      | 8       |
| 25-34      | 40      |
| 35-44      | 12      |
| 45-54      | 20      |
| 55-64      | 12      |
| 65 or over | 8       |

Average age: 41

BASE: Total charter boat operators (25)

Question: Which of the following categories includes your age?

Table 9.--Source of income.

| Response | Percent |
|----------|---------|
| Yes      | 56      |
| No       | 44      |

BASE: Total charter boat operators (25)

Question: Are you dependent upon this charter operation as your sole source of income?

Table 10.--Alternative sources of income.

| Percent of personal income<br>from charter operation | Percent |
|------------------------------------------------------|---------|
| None                                                 | 18      |
| 1-25                                                 | 18      |
| 26-50                                                | 18      |
| 51-75                                                | 18      |
| 76-99                                                | 27      |

Average percentage of income derived  
from charter operation 47

BASE: Charter boat operators not  
dependent on charter operation (11)  
as sole source of income

Question: What percent of your total personal income is derived from  
this charter operation?



Table 11.--Average earnings.

| Response             | Percent |
|----------------------|---------|
| Up to \$5,000        | 25      |
| \$5,001-\$10,000     | 38      |
| \$10,001-\$15,000    | 25      |
| \$15,001-\$20,000    | 13      |
| Average earnings     | \$8,750 |
| BASE: Skippers only  | (8)     |
| (no owners included) |         |

Question: As skipper of this boat, what were your personal gross earnings for the past year? Please include wages, tips, share-of-fish, and mount commissions.

Table 12.--Employment.

| Response | Full time<br>percent | Part time<br>percent |
|----------|----------------------|----------------------|
| None     | 0                    | 56                   |
| 1        | 16                   | 28                   |
| 2        | 76                   | 12                   |
| 3        | 8                    | 4                    |

BASE: Total charter boat operators (25) (25)

Question: How many persons, including yourself if applicable, are full-time/part-time employees of this charter operation?

### Business Earnings

The survey asked detailed questions (including voluntary review of logbooks and business records) concerning the operation of the charter boats, the number of full- and half-day trips, number of passengers per trip, number of pleasure (or "holoholo") trips, fees charged, earnings from fees, tips, and other revenues.

1. The average number of full-day charter trips taken during 1976 was 97, with 4 operators making fewer than 50 trips, and 13 making over 100 trips. The average number of half-day trip was 72.

2. Most operators carry an average of four passengers per trip.

3. The average fee was \$239 for a full-day charter and \$149 for a half-day charter.



4. Average annual gross income from charter boat operations was \$26,752 with an additional \$2,400 received from sale of fish. (Operators also distributed the catch to the crew for their own use or sale.) Including other sources of charter-related revenue (e.g., mounting fees), the average vessel grossed \$30,140 in 1976.

5. Average annual expenditures were \$31,476 which indicates that most vessels lost money on their charter boat operations. However, the impact of variable vessel financing rates (reflecting in particular the cost of new vessels) suggests that losses were overstated.

The following tables provide more information on vessel earnings and costs.

Table 13.--Number of full-day charter trips.

| Response              | Percent |
|-----------------------|---------|
| Less than 50          | 16      |
| 50-75                 | 20      |
| 76-100                | 8       |
| 101-125               | 32      |
| 126-150               | 20      |
| Do not know/no answer | 4       |

Average number of full-day trips 97

BASE: Total charter boat operators (25)

Question: First, how many full-day charter trips did this boat take out during the past year?

Table 14.--Number of half-day charter trips.

| Response              | Percent |
|-----------------------|---------|
| None                  | 4       |
| 20 or less            | 16      |
| 21-50                 | 16      |
| 51-75                 | 16      |
| 76-100                | 24      |
| 101-150               | 12      |
| More than 150         | 8       |
| Do not know/no answer | 4       |

Average number of half-day trips 72

BASE: Total charter boat operators (25)

Question: And how many half-day trips did this boat take?





Table 15.--Number of nonbusiness trips.

| Response      | Percent |
|---------------|---------|
| 5 or less     | 20      |
| 6-10          | 12      |
| 11-20         | 16      |
| 21-30         | 20      |
| 31-50         | 12      |
| 51-100        | 16      |
| More than 100 | 4       |

Average number of pleasure trips: 33

BASE: Total charter boat operators (25)

Question: How many trips did you make on this boat to fish for your own pleasure or to catch fish to sell. These would be trips when you did not carry any paying customers.

Table 16.--Number of customers per trip.

| Response    | Percent |
|-------------|---------|
| 2 customers | 4       |
| 2.5         | 8       |
| 3           | 8       |
| 3.5         | 8       |
| 4           | 64      |
| More than 4 | 8       |

Overall average number of customers: 4

BASE: Total charter boat operators (25)

Question: What is your average, or usual, number of customers per trip?

Table 17.--Full-day charter fees.

| Response        | Percent |
|-----------------|---------|
| Less than \$225 | 12      |
| \$225           | 20      |
| \$234           | 28      |
| \$250           | 20      |
| \$260 or more   | 20      |

Average charge for full-day charter \$239

BASE: Total charter boat operators (25)

Question: What is your usual charge for a full-day charter?



Table 18.--Half-day charter fees.

| Response                              | Percent |
|---------------------------------------|---------|
| \$100                                 | 8       |
| \$130                                 | 12      |
| \$137.50                              | 12      |
| \$140                                 | 20      |
| \$150                                 | 20      |
| \$175 or more                         | 16      |
| No answer/no half-day charter offered | 12      |

Average charge for half-day charter \$149

BASE: Total charter boat operators (25)

Question: What is your usual charge for a half-day charter?

Table 19.--Gross charter income in 1976.

| Response          | Percent |
|-------------------|---------|
| Less than \$5,000 | 4       |
| \$5,000-\$14,000  | 12      |
| \$15,000-\$19,000 | 8       |
| \$20,000-\$24,999 | 8       |
| \$25,000-\$29,999 | 32      |
| \$30,000-\$34,999 | 16      |
| \$35,000-\$39,999 | 4       |
| \$40,000 or more  | 16      |

Average gross annual income \$26,752

BASE: Total charter boat operators (25)

Question: During the past 12 months, what was the gross income of this charter operation, excluding commissions paid to booking agents?



Table 20.--Income from sale of fish.

| Response          | Percent |
|-------------------|---------|
| \$0/all to crew   | 32      |
| Less than \$1,000 | 12      |
| \$1,000-\$1,999   | 4       |
| \$2,000-\$2,499   | 16      |
| \$2,500-\$2,999   | 8       |
| \$3,000-\$3,999   | 12      |
| \$5,000 or more   | 16      |

Average earnings from sale of fish \$2,402

BASE: Total charter boat operators (25)

Question: What were the charter operation's earnings from the sale of fish?

Table 21.--Average combined income.

|                               | Charter<br>business<br>earnings<br>(mean) |
|-------------------------------|-------------------------------------------|
| Income from charter trips     | \$26,752                                  |
| Income from sale of fish      | 2,402                                     |
| Income from mount commissions | 986                                       |
| Total                         | \$30,140                                  |



Table 22.--Average annual expenditures.

| Item                                                                                                 | Operating costs |
|------------------------------------------------------------------------------------------------------|-----------------|
| Salaries and wages                                                                                   | \$8,518         |
| Repairs (includes engine/hull/electronic equipment/fishing tackle)                                   | 4,983           |
| Commissions to booking agencies, etc.                                                                | 4,053           |
| Boat fuel and oil                                                                                    | 3,361           |
| Fishing tackle (includes rods and reels/lures/hooks and leaders/line/skirts and leadheads)           | 2,801           |
| Insurance (includes marine hull and liability/health insurance for crew/other job-related insurance) | 2,345           |
| Boat payments                                                                                        | 1,595           |
| Advertising costs                                                                                    | 1,002           |
| Food and beverages                                                                                   | 643             |
| Ice                                                                                                  | 465             |
| Club or association fees                                                                             | 152             |
| Mooring fees                                                                                         | 86              |
| Tournament fees                                                                                      | 61              |
| Live bait                                                                                            | 42              |
| Other charter operation-related expenses                                                             | 1,369           |
| Total                                                                                                | \$31,476        |
| BASE: Total charter boat operators                                                                   | (25)            |

Table 23.--Boat payments.

| Response                              | Percent |
|---------------------------------------|---------|
| Nothing/no payments/<br>boat paid for | 76      |
| Less than \$5,000                     | 8       |
| \$5,001-\$10,000                      | 8       |
| \$10,001 or more                      | 8       |
| Average mortgage payment              | \$1,595 |

BASE: Total charter boat operators (25)

Question: What was paid on the boat mortgage for the past year, including both principal and interest?





Table 24.--Repairs.

| Response          | Percent |
|-------------------|---------|
| Less than \$1,000 | 8       |
| \$1,000-\$1,499   | 12      |
| \$1,400-\$1,999   | 12      |
| \$2,000-\$2,999   | 20      |
| \$3,000-\$3,999   | 12      |
| \$4,000-\$4,999   | 4       |
| \$5,000-\$9,999   | 12      |
| \$10,000-\$14,999 | 12      |
| \$15,000 or more  | 8       |

Average repair expenditure: \$4,983

BASE: Total charter boat operators (25)

Question: How much was spent on repairs? (Includes engine/hull/electronic equipment/fishing tackle)

Table 25.--Salaries and wages.

| Response          | Percent |
|-------------------|---------|
| \$0/none          | 4       |
| Less than \$2,500 | 8       |
| \$2,500-\$4,999   | 35      |
| \$5,000-\$9,999   | 20      |
| \$10,000-\$14,999 | 24      |
| \$15,000 or more  | 16      |

Average expenditure for salaries \$8,518

BASE: Total charter boat operators (25)

Question: How much did the charter operation pay in salaries and wages to crew members?



Table 26.--Insurance.

| Response          | Percent |
|-------------------|---------|
| \$0/nothing       | 4       |
| Less than \$1,500 | 12      |
| \$1,500-\$1,999   | 32      |
| \$2,000-\$2,499   | 20      |
| \$3,000 or more   | 20      |

Average insurance expenditure \$2,345

BASE: Total charter boat operators (25)

Question: How much did the charter operation pay for insurance including marine hull liability insurance, health insurance for crew members, and any other job-related insurance that you carry?

#### Fish Catch and Disposition

The following table lists the average charter boat catch by species, number, pounds, and revenue.

| Species                          | Number | Pounds caught | Revenue |
|----------------------------------|--------|---------------|---------|
| Blue marlin                      | 28     | 7,230         | \$ 875  |
| Ahi (yellowfin and bigeye tunas) | 33     | 3,238         | 1,865   |
| Ono (wahoo)                      | 43     | 1,113         | 823     |
| Aku (skipjack tuna)              | 397    | 915           | 18      |
| Mahimahi                         | 31     | 650           | 503     |
| Striped marlin                   | 4      | 572           | 84      |
| Black marlin                     | 2      | 544           | 71      |
| Shortbill spearfish              | 5      | 163           | 51      |
| Sailfish                         | --     | 5             | --      |



APPENDIX

CHARTER OPERATOR  
QUESTIONNAIRE

RESEARCH ASSOCIATES  
DECEMBER 1976

NAME OF BOAT \_\_\_\_\_

NAME OF OWNER OR SKIPPER \_\_\_\_\_

PIER \_\_\_\_\_

PHONE \_\_\_\_\_

INTERVIEWER \_\_\_\_\_

DATE OF INTERVIEW \_\_\_\_\_

LENGTH OF INTERVIEW \_\_\_\_\_

RA #03400



Hello, I'm \_\_\_\_\_ from Research Associates. We're working as consultants to the National Marine Fisheries Service to develop information about the value of commercial and recreational fishing to the people of the Kona Coast. Your frank and open answers will help provide the basis for a fisheries management plan which will benefit the local fishing industry here. All of your answers will be strictly confidential, of course.

I'd like to begin by asking some questions about your boat.....

Q.1 First, what is the length of your boat? \_\_\_\_\_ ft.

Q.2 And what is the horsepower of your engine/s? \_\_\_\_\_ hp.

Q.3 For how many years has your boat been in operation in Kona as a charter vessel?

\_\_\_\_\_ yrs.

Q.4 What was the cost of the boat when it was purchased?

\$ \_\_\_\_\_

Q.5 What would you say is the value of the boat today?

\$ \_\_\_\_\_

Q.6 Are you the owner of the boat, the skipper of the boat, or both?

1 ( ☐ ) owner

2 ( ☐ ) skipper

3 ( ☐ ) both

Q.7 How many persons, including yourself if applicable, are full-time employees of this charter operation?

\_\_\_\_\_

Q.8 And how many persons are part-time employees of this charter operation?

\_\_\_\_\_

Q.9 Do you keep a boat log or other kinds of records about the following items:

|                          | <u>Records</u>                 | <u>No Records</u>              |
|--------------------------|--------------------------------|--------------------------------|
| Number of charter trips  | 1 ( <input type="checkbox"/> ) | 2 ( <input type="checkbox"/> ) |
| Number of persons aboard | 1 ( <input type="checkbox"/> ) | 2 ( <input type="checkbox"/> ) |
| Hours at sea             | 1 ( <input type="checkbox"/> ) | 2 ( <input type="checkbox"/> ) |
| Engine time              | 1 ( <input type="checkbox"/> ) | 2 ( <input type="checkbox"/> ) |
| Fish caught              | 1 ( <input type="checkbox"/> ) | 2 ( <input type="checkbox"/> ) |
| Boat expenditures        | 1 ( <input type="checkbox"/> ) | 2 ( <input type="checkbox"/> ) |
| Boat revenues            | 1 ( <input type="checkbox"/> ) | 2 ( <input type="checkbox"/> ) |





Q.10 Are you a member of a charter operators' association, or are you an independent operator?

1 ( ) association member

2 ( ) independent

The questions I have for you now deal with revenues, customers, expenditures, and fish catches for the past twelve months...that would be from December 1975 to the present date. Please answer from your records, if possible. If you have no available records, we will need your best estimate.....(RECORD ESTIMATES WITH AN "E"; RESPONSES FROM RECORDS WITH AN "R")

Q.11 First, how many full-day charter trips did this boat take out during the past year?

---

Q.12 And how many half-day trips did this boat take?

---

Q.13 What is your average, or usual, number of customers per trip?

---

Q.14 How many fishing trips did you make on this boat to fish for your own pleasure or to catch fish to sell? These would be trips when you did not carry any paying customers.

---



Now, we need to have some information about your fish catches for the past year. For this study, we are interested in the larger, open-ocean fish such as ono, ahi, aku, mahi-mahi, and different marlin species.....

|                     | a.                                                                     | b.                      | c.                | d.                                                    | e.                          | f.                                                     |
|---------------------|------------------------------------------------------------------------|-------------------------|-------------------|-------------------------------------------------------|-----------------------------|--------------------------------------------------------|
| Q.15                | Did you catch any (name) during the past twelve months?                | How many did you catch? | Total lbs. caught | How many lbs. did you keep for yourself or give away? | How many lbs. did you sell? | What were your total earnings from the sale of (name)? |
| Ono                 | Caught <input type="checkbox"/><br>Not Caught <input type="checkbox"/> |                         |                   |                                                       |                             |                                                        |
| Ahi                 | Caught <input type="checkbox"/><br>Not Caught <input type="checkbox"/> |                         |                   |                                                       |                             |                                                        |
| Aku                 | Caught <input type="checkbox"/><br>Not Caught <input type="checkbox"/> |                         |                   |                                                       |                             |                                                        |
| Mahi-mahi           | Caught <input type="checkbox"/><br>Not Caught <input type="checkbox"/> |                         |                   |                                                       |                             |                                                        |
| Blue marlin         | Caught <input type="checkbox"/><br>Not Caught <input type="checkbox"/> |                         |                   |                                                       |                             |                                                        |
| Black marlin        | Caught <input type="checkbox"/><br>Not Caught <input type="checkbox"/> |                         |                   |                                                       |                             |                                                        |
| Striped marlin      | Caught <input type="checkbox"/><br>Not Caught <input type="checkbox"/> |                         |                   |                                                       |                             |                                                        |
| Shortbill spearfish | Caught <input type="checkbox"/><br>Not Caught <input type="checkbox"/> |                         |                   |                                                       |                             |                                                        |
| Sailfish            | Caught <input type="checkbox"/><br>Not Caught <input type="checkbox"/> |                         |                   |                                                       |                             |                                                        |

(GO THROUGH QUESTIONS a, b, c, d, e, and f FOR EACH FISH LISTED)



|                                                                                                                                                                                                |                                       |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|--|
| a. What was paid on the boat mortgage for the past year, including both principal and interest?                                                                                                | Boat Payments                         |  |
| b. What were the mooring fees for the past year?                                                                                                                                               | Mooring Fees                          |  |
| c. How much was spent on fuel and oil for the boat?                                                                                                                                            | Boat Fuel and Oil                     |  |
| d. How much was spent on engine repairs? repairs on the hull? repairs on any electronic equipment? fishing tackle repairs?                                                                     | Engine Repairs                        |  |
|                                                                                                                                                                                                | Hull Repairs                          |  |
|                                                                                                                                                                                                | Electronic Equipment Repairs          |  |
|                                                                                                                                                                                                | Fishing Tackle Repairs                |  |
| e. How much was spent for fishing tackle, including rods and reels, lures, hooks and leaders, line, and skirts and leadheads?                                                                  | Fishing Tackle                        |  |
| f. How much was spent for live bait?                                                                                                                                                           | Live Bait                             |  |
| g. How much was spent for ice?                                                                                                                                                                 | Ice                                   |  |
| h. How much did the charter operation pay in salaries and wages to crew members? in share-of-fish? in share-of-mount commissions?                                                              | Salaries and Wages                    |  |
|                                                                                                                                                                                                | Share-of-Fish                         |  |
|                                                                                                                                                                                                | Share-of-Mount Commissions            |  |
| i. How much did the charter operation pay in commissions to booking agencies, travel agents, and others?                                                                                       | Commissions to Booking Agencies, etc. |  |
| j. How much did the charter operation pay for insurance, including marine hull and liability insurance, health insurance for crew members, and any other job-related insurance that you carry? | Insurance                             |  |
| k. How much was paid for advertising and promotion?                                                                                                                                            | Advertising Costs                     |  |
| l. How much was spent for food and beverages for yourself, your crew, and/or your passengers?                                                                                                  | Food and Beverages                    |  |
| m. How much was spent for club or association fees?                                                                                                                                            | Club or Association Fees              |  |
| n. How much was spent for tournament fees?                                                                                                                                                     | Tournament Fees                       |  |
| o. Can you think of any other charter operation-related expenses that were incurred during the past year that we haven't mentioned? If so, what are they and how much did you spend?           | Other                                 |  |
|                                                                                                                                                                                                |                                       |  |
|                                                                                                                                                                                                |                                       |  |
|                                                                                                                                                                                                |                                       |  |



Q.17 Do you personally do any of your own repairs and maintenance on the boat or fishing equipment?

- 1 ( ) Yes \_\_\_\_\_  
2 ( ) No (SKIP TO Q.18) \_\_\_\_\_

Q.17a About how many hours would you say you have spent working on boat-related repairs and maintenance in the past twelve months?

\_\_\_\_\_ hours

Q.18 Does the business have a vehicle to transport customers from their hotel to the pier and back and/or a vehicle to haul fish?

- 1 ( ) no vehicle (SKIP TO Q.19)  
2 ( ) vehicle to transport customers \_\_\_\_\_  
3 ( ) vehicle to haul fish \_\_\_\_\_  
4 ( ) both \_\_\_\_\_

Q.18a How much was spent on fuel and oil for this/these vehicle/s?

\$ \_\_\_\_\_

Q.18b How much was spent for maintenance and repair of this/these vehicle/s?

\$ \_\_\_\_\_

Q.18c And how much was spent for insurance for this/these vehicle/s?

\$ \_\_\_\_\_

Q.18d Over the past twelve months, how much was spent on loan payments for this/these vehicle/s?

\$ \_\_\_\_\_

Fine.....the next area of questioning deals with the earnings of the charter operation over the past twelve months. Again, please check your records, if possible. Otherwise we will need your best estimate.

Q.19 First, what is your usual charge for a full-day charter? \$ \_\_\_\_\_

Q.20 And what is your usual charge for a half-day charter? \$ \_\_\_\_\_

Q.21 During the past twelve months, what was the gross income of this charter operation excluding commissions paid to booking agents?

\$ \_\_\_\_\_

Q.22 What were the charter operation's earnings from the sale of fish?

\$ \_\_\_\_\_

Q.23 What were the charter operation's earnings from mount commissions?

\$ \_\_\_\_\_

Q.24 About how much did the crew earn in tips during the past twelve months?

\$ \_\_\_\_\_





Q.25 Are you dependent upon this charter operation as your sole source of income?

1 ( ) Yes (GO TO Q.26)

2 ( ) No 

Q.25a. What percent of your total personal income is derived from this charter operation?

\_\_\_\_\_ %

Q.26 How many others on your crew, if any, are dependent upon this charter operation as their sole source of income?

\_\_\_\_\_

(SKIP Q.27 IF INTERVIEWING OWNER)

Q.27 (FOR SKIPPERS ONLY) As skipper of this boat, what were your personal gross earnings for the past year? Please include wages, tips, share-of-fish, and mount commissions. (SHOW CARD AND RECORD LETTER NEXT TO APPROPRIATE CATEGORY)

\_\_\_\_\_

Q.28 Which of the following categories includes your age?

1 ( ) 18 - 24 years

5 ( ) 55 - 64 years

2 ( ) 25 - 34 years

6 ( ) 65 years and over

3 ( ) 35 - 44 years

7 ( ) Refused

4 ( ) 45 - 54 years

Thank you very much for your help. I'd like to mention again that the information you have given us will be held in strictest confidence and will not be identified with you personally or with your name.

Mahalo!

Sex of Respondent (RECORD, DO NOT ASK)

1 ( ) Male

2 ( ) Female





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STUDY OF BIO-ECONOMICS AND OPTIMAL MANAGEMENT CRITERIA  
FOR UTILIZATION OF PACIFIC BILLFISH  
MODULE I

PREPARED FOR:  
NATIONAL MARINE FISHERIES SERVICE  
HONOLULU LABORATORY

BY:  
RESEARCH ASSOCIATES

JULY 1977









**U.S. DEPARTMENT OF COMMERCE**  
**National Oceanic and Atmospheric Administration**  
NATIONAL MARINE FISHERIES SERVICE  
Southwest Fisheries Center  
Honolulu Laboratory  
P. O. Box 3830  
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THE 1976-78 STUDIES OF THE  
KAILUA-KONA, HAWAII, BILLFISH FISHERY  
PART III  
CHARTER BOAT PATRONS COMPONENT

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## INTRODUCTION

This report is the last of three presenting the major findings of a series of surveys undertaken in 1976-78 on the billfish fisheries in Kailua-Kona, Hawaii. The present report contains information on a survey of charter boat patrons who participated in the Kailua-Kona fishery in 1977. The previous reports (1) presented information on commercial and recreational fishing and charter boat operators.

The surveys were conducted by Research Associates, Inc. under contract to the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service (NMFS). A personal interview survey of charter boat customers was fielded in the period January through August 1977 and augmented by further surveys in late 1977. This report is a condensed and edited version of the relevant portions of the contract reports submitted by Research Associates'. It complements ongoing research into charter boat fishing in Hawaii being conducted by NMFS and the University of Hawaii, College of Tropical Agriculture.

Additional interviews and data gathering activities in the project included:

1. personal interviews with officials of charter boat associations in Kona;
2. personal interviews with seafood brokers in Kona and Hilo;
3. a followup telephone survey of 100 of the commercial and recreational fishers originally surveyed;
4. a followup mail and telephone survey of 201 of the charter boat customers during January-September 1977 who resided on the mainland U.S.;
5. a statistical projection of records obtained through the Kona Activities Association (a charter boat operators association); and,
6. a review of the complementarity of Hawaii Division of Aquatic Resources catch reports with data obtained from Kona.

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<sup>1</sup>National Marine Fisheries Service. 1982. The 1976-78 studies of the Kailua-Kona, Hawaii, billfish fishery, Part I, commercial/recreational component. Southwest Fish. Cent. Admin. Rep. H-82-3, 22 p. + Appendix. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

<sup>2</sup>National Marine Fisheries Service. 1983. The 1976-78 studies of the Kailua-Kona, Hawaii, billfish fishery, Part II, charter boat operators component. Southwest Fish. Cent. Admin. Rep. H-83-4, 13 p. + Appendix. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.



The information obtained from most of these additional surveys were compiled only into computer-generated tables. Most of the original material is available at the Honolulu Laboratory.

## SURVEY RESULTS

### Sampling

A personal interview approach was selected to gather the most complete and accurate information from the charter boat patrons as was done for the commercial, recreational, and charter boat operators components. This method offered the opportunity for interviewers to develop rapport with respondents and reassure them about the goals of the study and the confidentiality of the information gathered. Research Associates' utilized charter boat operators and professional interviewers to undertake the survey.

Interviews were stratified into five components: out-of-state visitors (on tour or traveling independently), State of Hawaii residents (tour or independent), and County of Hawaii residents. This report only provides information on the out-of-state charter boat customers.

### Results

Questions were reported for five areas of interest: reasons for traveling to Kailua-Kona (Island of Hawaii) and for going deep-sea fishing, relationship of the visit to Kailua-Kona to the tourist's entire vacation in the Hawaii, expenditures on deep-sea fishing, general travel expenditures, and demographics. The following tables from the report by Research Associates record the responses to these questions. References to "Big Island" in the following tables are to the Island of Hawaii (Hawaii County).



SAMPLE  
DISTRIBUTION

| <u>Month</u>            | <u>Out-of-State Visitor</u> |             |                    |
|-------------------------|-----------------------------|-------------|--------------------|
|                         | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| January                 | 12%                         | 6%          | 14%                |
| February                | 44                          | 29          | 50                 |
| March                   | 8                           | 6           | 10                 |
| April                   | 2                           | -           | 2                  |
| May                     | 3                           | 12          | -                  |
| June                    | 12                          | 18          | 10                 |
| July                    | 14                          | 24          | 10                 |
| August                  | 5                           | 6           | 5                  |
| BASE: Total Respondents | (59)                        | (17)        | (42)               |





Q. When did you first consider going deep-sea fishing here in Kona? I'll read you some choices.

|                                                     | Out-of-State Visitor |             |                    |
|-----------------------------------------------------|----------------------|-------------|--------------------|
|                                                     | <u>Total</u>         | <u>Tour</u> | <u>Independent</u> |
| Before leaving the Mainland or country of residence | 63%                  | 59%         | 64%                |
| After arrival in Kona                               | 29                   | 35          | 26                 |
| After arrival on another island in Hawaii           | 7                    | 6           | 7                  |
| No response                                         | 2                    | -           | 2                  |
| BASE: Total Respondents                             | (59)                 | (17)        | (42)               |



- Q. Now I'd like you to assign some percentages to the importance of your deep-sea fishing trip to your visit. Deep-sea fishing would have a very high percentage of importance, for example, if you came to Kona strictly to go deep-sea fishing. You should assign a low percentage importance if this fishing trip was incidental to your visit here. Okay, what percentage importance did this deep-sea fishing trip have on:

|                                                                                  | AVERAGE PERCENTAGE   |             |                    |
|----------------------------------------------------------------------------------|----------------------|-------------|--------------------|
|                                                                                  | Out-of-State Visitor |             |                    |
|                                                                                  | <u>Total</u>         | <u>Tour</u> | <u>Independent</u> |
| Your decision to visit the Big Island                                            | 66%                  | 72%         | 64%                |
| Your decision to visit the State of Hawaii                                       | 42                   | 40          | 42                 |
| BASE: Respondents who considered going deep-sea fishing prior to arrival in Kona | (42)                 | (11)        | (31)               |



Q. How many people on this fishing trip, including yourself, belong to your immediate travel party?

| <u>Response</u>           | <u>Out-of-State Visitor</u> |             |                    |
|---------------------------|-----------------------------|-------------|--------------------|
|                           | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| One                       | 44%                         | 53%         | 40%                |
| Two                       | 36                          | 41          | 33                 |
| Three                     | 3                           | --          | 5                  |
| Four                      | 8                           | 6           | 10                 |
| Five                      | 5                           | -           | 7                  |
| Six                       | 2                           | -           | 2                  |
| No response               | 2                           | -           | 2                  |
| Average number of persons | 1.9                         | 1.6         | 2.1                |
| BASE: Total Respondents   | (59)                        | (17)        | (42)               |



Q. Was there anyone in your immediate travel party who did not go fishing on this trip with you?

| <u>Response</u>                | <u>Out-of-State Visitor</u> |             |                    |
|--------------------------------|-----------------------------|-------------|--------------------|
|                                | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| No                             | 41%                         | 47%         | 38%                |
| Yes                            | 59                          | 53          | 62                 |
| Number who did not go fishing: |                             |             |                    |
| One                            | 34%                         | 47%         | 29%                |
| Two                            | 14                          | -           | 19                 |
| Three                          | 8                           | 6           | 10                 |
| Four or more                   | 3                           | -           | 5                  |
| Average number                 | 1.0                         | .6          | 1.2                |
| BASE: Total Respondents        | (59)                        | (17)        | (42)               |





Q. Have you already gone on other deep-sea fishing trips in Kona during this visit?

| <u>Response</u>         | <u>Out-of State Visitor</u> |             |                    |
|-------------------------|-----------------------------|-------------|--------------------|
|                         | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| No                      | 92%                         | 94%         | 90%                |
| Yes                     | 8                           | 6           | 10                 |
| BASE: Total Respondents | (59)                        | (17)        | (42)               |



Q. Do you plan to go deep-sea fishing again on this visit to Kona?

| <u>Response</u>                                                              | <u>Out-of-State Visitor</u> |             |                    |
|------------------------------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                                              | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| No                                                                           | 81%                         | 88%         | 79%                |
| Yes                                                                          | 17                          | 6           | 21                 |
| Don't know/undecided                                                         | 2                           | 6           | -                  |
| Average number total fishing<br>trips taken (including this<br>fishing trip) | 1.8                         | 1.2         | 2.0                |
| BASE: Total Respondents                                                      | (59)                        | (17)        | (42)               |



Q. Do you plan to go deep-sea fishing again on this visit to Kona?

| <u>Response</u>                                                        | <u>Out-of-State Visitor</u> |             |                    |
|------------------------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                                        | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| No                                                                     | 81%                         | 88%         | 79%                |
| Yes                                                                    | 17                          | 6           | 21                 |
| Don't know/undecided                                                   | 2                           | 6           | -                  |
| Average number total fishing trips taken (including this fishing trip) | 1.8                         | 1.2         | 2.0                |
| BASE: Total Respondents                                                | (59)                        | (17)        | (42)               |



IMAGE RATINGS

- MEAN RATINGS -

|                                                                                               | <u>Out-of-State Visitor</u> |             |                    |
|-----------------------------------------------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                                                               | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| Importance of deep-sea fishing<br>as a vacation/leisure activity                              | 6.7                         | 6.7         | 6.7                |
| Deep-sea fishing in Hawaii as<br>compared to other places                                     | 7.1                         | 6.9         | 7.2                |
| Rating of deep-sea fishing<br>relative to other activities<br>for visitors on Big Island      | 7.6                         | 7.7         | 7.5                |
| Rating of deep-sea fishing<br>relative to other activities<br>for visitors in State of Hawaii | 6.6                         | 6.2         | 6.7                |
| BASE: Total Respondents                                                                       | (59)                        | (17)        | (42)               |

Response ranked on a scale of 1 to 10.





- Q. What other islands have you visited so far on this trip to Hawaii?  
 What other islands do you intend to visit on this trip?  
 How many nights did you stay/do you plan to stay on that island?

| <u>Islands Visited</u>       | <u>Out-of-State Visitor</u> |             |                    |
|------------------------------|-----------------------------|-------------|--------------------|
|                              | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| <u>Oahu</u>                  |                             |             |                    |
| Travel party visited Oahu    | 88%                         | 94%         | 71%                |
| Average # nights spent       | 3.9                         | 3.8         | 4.2                |
| <u>Maui</u>                  |                             |             |                    |
| Travel party visited Maui    | 63%                         | 82%         | 45%                |
| Average # nights spent       | 3.8                         | 4.7         | 2.5                |
| <u>Kauai</u>                 |                             |             |                    |
| Travel party visited Kauai   | 48%                         | 71%         | 31%                |
| Average # nights spent       | 3.2                         | 3.8         | 2.6                |
| <u>Molokai</u>               |                             |             |                    |
| Travel party visited Molokai | 4%                          | -           | 5%                 |
| Average # nights spent       | 1.5                         | -           | 1.5                |
| BASE: Total Respondents      | (59)                        | (17)        | (42)               |



Q. Is this your first visit to the State of Hawaii, or have you been here before?

| <u>Response</u>         | <u>Out-of-State Visitor</u> |             |                    |
|-------------------------|-----------------------------|-------------|--------------------|
|                         | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| First Visit             | 54%                         | 94%         | 38%                |
| Repeat Visit            | 44                          | 6           | 60                 |
| No response             | 2                           | -           | 2                  |
| BASE: Total Respondents | (59)                        | (17)        | (42)               |

Q. Aside from this trip, how many visits have you made to the State of Hawaii?

| <u>Response</u>                              | <u>Out-of-State Visitor</u> |             |                    |
|----------------------------------------------|-----------------------------|-------------|--------------------|
|                                              | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| Average number visits to the State of Hawaii | 4.7                         | 1.0         | 4.8                |
| BASE: Repeat Visitors                        | (26)                        | (1)         | (25)               |

Q. And how many times did that include a visit to the Big Island?

| <u>Response</u>        | <u>Out-of-State Visitor</u> |             |                    |
|------------------------|-----------------------------|-------------|--------------------|
|                        | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| None                   | 28%                         | 100%        | 25%                |
| Average number visits: | 2.9                         | -           | 2.9                |
| BASE: Repeat Visitors  | (26)                        | (1)         | (25)               |

Q. How many times before this visit have you gone fishing here in Kona?

| <u>Response</u>                                              | <u>Percent</u> |
|--------------------------------------------------------------|----------------|
| None                                                         | 78%            |
| Average number of trips:                                     | 3.0            |
| BASE: Repeat visitors who have visited Big Island previously | (18)           |



Q. When do you plan to next visit the State of Hawaii?

| <u>Response</u>            | <u>Out-of-State Visitor</u> |             |                    |
|----------------------------|-----------------------------|-------------|--------------------|
|                            | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| Don't know/undecided       | 41%                         | 59%         | 33%                |
| Don't plan to visit again  | 2                           | 6           | -                  |
| 1977/within the year       | 12                          | -           | 17                 |
| 1978                       | 14                          | -           | 19                 |
| In two years               | 12                          | 6           | 14                 |
| Two to three years or more | 19                          | 29          | 14                 |
| No response                | 2                           | -           | 2                  |
| BASE: Total Respondents    | (59)                        | (17)        | (42)               |



Q. Will your next visit include a trip to this island?

| <u>Response</u>         | <u>Out-of-State Visitor</u> |             |                    |
|-------------------------|-----------------------------|-------------|--------------------|
|                         | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| Yes                     | 51%                         | 41%         | 55%                |
| No                      | 2                           | -           | 2                  |
| Maybe                   | 5                           | -           | 7                  |
| Don't know/undecided    | 42                          | 59          | 36                 |
| BASE: Total Respondents | (59)                        | (17)        | (42)               |





Q. Will you go deep-sea fishing here on your next visit to the Big Island?

| <u>Response</u>         | <u>Out-of-State Visitor</u> |             |                    |
|-------------------------|-----------------------------|-------------|--------------------|
|                         | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| Yes                     | 49%                         | 47%         | 50%                |
| No                      | 2                           | -           | 2                  |
| Maybe                   | 8                           | -           | 12                 |
| Don't know/undecided    | 41                          | 53          | 36                 |
| BASE: Total Respondents | (59)                        | (17)        | (42)               |



- Q. We'd like to get an idea of the expenditures made by all the people in your immediate travel party for this particular fishing trip. I'll read you a list of expense items. I'd like you to tell me the amount of money you or other people in your travel party spent on each item for your fishing trip today. Don't forget to include all amounts spent in the form of cash, check, or credit card.

| <u>Rental Fee to Boat<br/>Charter-Boat Operator</u>                   | <u>Out-of-State Visitor</u> |             |                    |
|-----------------------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                                       | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| Average fee paid                                                      | \$110                       | \$114       | \$99               |
| <u>Transportation from lodging<br/>to boat and return</u>             |                             |             |                    |
| No expenditure                                                        | 93%                         | 88%         | 95%                |
| Average expenditure (total)                                           | \$0.40                      | \$0.47      | \$0.37             |
| Average expenditure (among<br>those making an expenditure)            | \$5.85                      | \$4.00      | \$7.70             |
| <u>Food and Beverage intended for<br/>consumption on fishing trip</u> |                             |             |                    |
| No expenditure                                                        | 29%                         | 47%         | 21%                |
| Average expenditure (total)                                           | \$4.18                      | \$2.77      | \$4.75             |
| Average expenditure (among<br>those making an expenditure)            | \$5.87                      | \$5.23      | \$6.05             |
| <u>Special Fishing Tackle</u>                                         |                             |             |                    |
| No expenditure                                                        | 2%                          | 6%          | -                  |
| Average expenditure (total)                                           | \$0.10*                     | \$0.35*     | —*                 |
| Average expenditure (among<br>those making an expenditure)            | \$6.00*                     | \$6.00*     | —*                 |

\*Single response



| <u>Special apparel, such as hats, gloves, etc.</u>                            | <u>Out-of-State Visitor</u> |             |                    |
|-------------------------------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                                               | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| No expenditure                                                                | 88%                         | 100%        | 59%                |
| Average expenditure (total)                                                   | \$1.12                      | -           | \$1.57             |
| Average expenditure (among those making an expenditure)                       | \$9.43                      | -           | \$9.43             |
| <br><u>Sundry items, such as suntan lotion, seasick pills, photo supplies</u> |                             |             |                    |
| No expenditure                                                                | 81%                         | 94%         | 76%                |
| Average expenditure (total)                                                   | \$1.27                      | \$0.06      | \$1.76             |
| Average expenditure (among those making an expenditure)                       | \$6.82                      | \$1.00*     | \$7.40             |
| <br><u>Other fishing related expenses</u>                                     |                             |             |                    |
| No expenditure                                                                | 98%                         | 100%        | 98%                |
| Average expenditure (total)                                                   | \$0.08                      | -           | \$0.12             |
| Average expenditure (among those making an expenditure)                       | \$6.00*                     | -           | \$6.00*            |
| <br>BASE: Total respondents                                                   | <br>(59)                    | <br>(17)    | <br>(42)           |

\*Single response



- Q. (ASKED IF RESPONDENT HAD TAKEN ON PLANNED TO TAKE OTHER FISHING TRIPS)  
On these other trips, would you say that your expenses for the charter fishing trip(s) were/will be:

| <u>Response</u>                                                             | <u>Out-of-State Visitor</u> |             |                    |
|-----------------------------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                                             | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| About the same as those today                                               | 85%                         | 50%         | 91%                |
| Don't know/no response                                                      | 15                          | 50%         | 9                  |
| BASE: Respondents who had taken previous trips/planned to take future trips | (13)                        | (2)         | (11)               |





DURATION OF BIG ISLAND STAY

|                                                        | Out-of-State Visitor |             |                    |
|--------------------------------------------------------|----------------------|-------------|--------------------|
|                                                        | <u>Total</u>         | <u>Tour</u> | <u>Independent</u> |
| Average number of days<br>spent in Kona on visit       | 6.9                  | 2.9         | 8.5                |
| Average number of nights<br>spent in Kona on visit     | 6.4                  | 2.9         | 7.9                |
| Average number days spent<br>elsewhere on Big Island   | .5                   | .6          | .5                 |
| Average number nights spent<br>elsewhere on Big Island | .4                   | .5          | .4                 |
| BASE: Total Respondents                                | (59)                 | (17)        | (42)               |



## FOOD AND BEVERAGE EXPENDITURES

| <u>Breakfast</u>                                        | <u>Out-of-State Visitor</u> |             |                    |
|---------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                         | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| No expenditure                                          | 20%                         | 41%         | 13%                |
| Average expenditure (total)                             | \$6.16                      | \$4.88      | \$6.70             |
| Average expenditure (among those making an expenditure) | \$7.73                      | \$7.80      | \$7.71             |
| <br><u>Lunch</u>                                        |                             |             |                    |
| No expenditure                                          | 5%                          | 6%          | 5%                 |
| Average expenditure (total)                             | \$9.95                      | \$8.59      | \$10.57            |
| Average expenditure (among those making an expenditure) | \$10.53                     | \$9.13      | \$11.15            |
| <br><u>Dinner</u>                                       |                             |             |                    |
| No expenditure                                          | 15%                         | 29%         | 8%                 |
| Average expenditure (total)                             | \$24.96                     | \$14.42     | \$29.82            |
| Average expenditure (among those making an expenditure) | \$29.21                     | \$20.00     | \$32.37            |
| <br><u>Snacks</u>                                       |                             |             |                    |
| No expenditure                                          | 40%                         | 59%         | 32%                |
| Average expenditure (total)                             | \$3.76                      | \$1.18      | \$4.92             |
| Average expenditure (among those making an expenditure) | \$4.81                      | \$2.00      | \$7.19             |
| BASE: Total Respondents                                 | (59)                        | (17)        | (42)               |



## OTHER EXPENDITURES

| <u>Lodging</u>                                          | <u>Out-of-State-Visitor</u> |             |                    |
|---------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                         | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| No expenditure                                          | 36%                         | 94%         | 11%                |
| Average expenditure (total)                             | \$29.66                     | \$1.12*     | \$42.43            |
| Average expenditure (among those making an expenditure) | \$46.61                     | \$19.00*    | \$47.43            |
| <u>Entertainment and Sightseeing</u>                    |                             |             |                    |
| No expenditure                                          | 89%                         | 94%         | 87%                |
| Average expenditure (total)                             | \$2.27                      | \$0.59      | \$3.03             |
| Average expenditure (among those making an expenditure) | \$20.83                     | \$10.00*    | \$23.00            |
| <u>Car Rental Including Gas</u>                         |                             |             |                    |
| No expenditure                                          | 55%                         | 94%         | 37%                |
| Average expenditure (total)                             | \$9.11                      | \$1.18      | \$12.66            |
| Average expenditure (among those making an expenditure) | \$20.04                     | \$20.00*    | \$20.04            |
| <u>Other transportation</u>                             |                             |             |                    |
| No expenditure                                          | 93%                         | 100%        | 92%                |
| Average expenditure (total)                             | \$0.93                      | -           | \$1.33             |
| Average expenditure (among those making an expenditure) | \$13.00                     | -           | \$13.00            |
| <u>Tips to airport/hotel personnel</u>                  |                             |             |                    |
| No expenditure                                          | 40%                         | 35%         | 42%                |
| Average expenditure (total)                             | \$2.15                      | \$1.53      | \$2.42             |
| Average expenditure (among those making an expenditure) | \$5.36                      | \$4.33      | \$5.75             |

(Continued)



| <u>Gifts, souvenirs</u>                                          | <u>Out-of-State Visitor</u> |             |                    |
|------------------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                                  | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| No expenditure                                                   | 53%                         | 65%         | 47%                |
| Average expenditure (total)                                      | \$28.65                     | \$15.65     | \$34.47            |
| Average expenditure (among those making an expenditure)          | \$60.62                     | \$44.33     | \$65.50            |
| <br><u>Clothing</u>                                              |                             |             |                    |
| No expenditure                                                   | 71%                         | 82%         | 66%                |
| Average expenditure (total)                                      | \$13.04                     | \$8.94      | \$14.87            |
| Average expenditure (among those making an expenditure)          | \$44.81                     | \$50.67     | \$43.46            |
| <br><u>Sundry items such as film, suntan lotion, health aids</u> |                             |             |                    |
| No expenditure                                                   | 62%                         | 55%         | 76%                |
| Average expenditure (total)                                      | \$3.27                      | \$0.47      | \$4.53             |
| Average expenditure (among those making an expenditure)          | \$8.57                      | \$2.00      | \$10.12            |
| <br><u>Other expenditures</u>                                    |                             |             |                    |
| No other expenditures                                            | 75%                         | 71%         | 76%                |
| Average expenditure (total)                                      | \$5.60                      | \$8.24      | \$4.42             |
| Average expenditure (among those making an expenditure)          | \$22.00                     | \$28.00     | \$18.67            |
| BASE: Total Respondents                                          | (59)                        | (17)        | (42)               |

\*Single response.





- Q. Would you say that your expenditures of yesterday were typical of your average daily expenditures (or expected expenditures) while on the Big Island?

| <u>Response</u>         | <u>Out-of-State Visitor</u> |             |                    |
|-------------------------|-----------------------------|-------------|--------------------|
|                         | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| Yes                     | 83%                         | 94%         | 79%                |
| No                      | 15                          | 6           | 19                 |
| No response             | 2                           | -           | 2                  |
| BASE: Total Respondents | (59)                        | (17)        | (42)               |

- Q. Were your expenditures yesterday more or less than your past or anticipated daily expenditures during this stay on the Big Island?

| <u>Response</u>                                                                                     | <u>Out-of-State Visitor</u> |             |                    |
|-----------------------------------------------------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                                                                     | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| More                                                                                                | 22%                         | -           | 25%                |
| Less                                                                                                | 78                          | 100%        | 75                 |
| BASE: Respondents whose previous day's expenditures were not typical of average daily expenditures. | (9)                         | (1)         | (8)                |



Q. Was your airfare or SeaFlite fare to and from this island included with your round-trip Hawaii tickets? (Not asked of Tour Travelers)

| <u>Response</u>             | <u>Percent</u> |
|-----------------------------|----------------|
| Yes                         | 71%            |
| No                          | 19             |
| Flew direct                 | 7              |
| No response                 | 3              |
| BASE: Independent travelers | (42)           |

Q. How much have you spent or do you expect to spend on airfare or SeaFlite trips to and from this island for everyone in your travel party?

|                                                |         |
|------------------------------------------------|---------|
| Average expenditure for airfare<br>or SeaFlite | \$81.38 |
|------------------------------------------------|---------|

|                                                                               |     |
|-------------------------------------------------------------------------------|-----|
| BASE: Respondents whose fare<br>was not included in<br>round-trip Hawaii fare | (8) |
|-------------------------------------------------------------------------------|-----|



Q. How much was spent altogether for airfare for your travel party's round-trip tickets to and from the State of Hawaii?

|                                                             |            |
|-------------------------------------------------------------|------------|
| Average expenditure for round-trip tickets per travel party | \$1,334.95 |
|-------------------------------------------------------------|------------|

Q. How many people age 12 and over did this cover?

| <u>Response</u>             | <u>Percent</u> |
|-----------------------------|----------------|
| One                         | 5%             |
| Two                         | 52             |
| Three                       | 10             |
| Four                        | 21             |
| Five                        | 10             |
| Six                         | 2              |
| BASE: Independent travelers | (42)           |

Q. How many children under 12?

| <u>Response</u>             | <u>Percent</u> |
|-----------------------------|----------------|
| None                        | 86%            |
| One                         | 7              |
| Two                         | 7              |
| BASE: Independent travelers | (42)           |

|                                                                                                      |     |
|------------------------------------------------------------------------------------------------------|-----|
| Average number of passengers per travel party (children under 12 counted at $\frac{1}{2}$ fare rate) | 3.0 |
|------------------------------------------------------------------------------------------------------|-----|



Q. What was the total price of your tour package for your trip to Hawaii?

|                               |           |
|-------------------------------|-----------|
| Average price of tour package | \$1815.13 |
|-------------------------------|-----------|

|                                                  |     |
|--------------------------------------------------|-----|
| Average number of persons<br>included in package | 2.1 |
|--------------------------------------------------|-----|

|                      |      |
|----------------------|------|
| BASE: Tour Travelers | (17) |
|----------------------|------|





OTHER EXPENSES INCLUDED IN PACKAGE

| <u>Charter Fishing Trip in Kona</u> | <u>Percent</u> |
|-------------------------------------|----------------|
| Included in package                 | 6%             |
| Not included in package             | 94             |
| <u>Airfares</u>                     |                |
| All airfares included in package    | 100%           |
| <u>Meals in Kona</u>                |                |
| Meals included in package           | 24%            |
| No meals included                   | 76             |
| <u>Sightseeing Tours</u>            |                |
| Sightseeing tour in Kona included   | 41%            |
| No sightseeing included             | 59             |
| BASE: Tour Travelers                | (17)           |



- Q. Well, we've asked you some detailed questions about your expenditures for fishing and your visit to this island. Now I'd like you to consider the expenses you've incurred or plan to incur for your visits to any other islands on this trip. What proportion of your total expenses does your visit to Kona represent?  
(ASKED ONLY OF INDEPENDENT TRAVELERS)

Average proportion of total expenses  
represented by Kona visit:

53%

BASE: Independent travelers

(42)



TIPS PAID AND FISH MOUNT COSTS

| <u>Tips paid to charter-boat operator<br/>and crew</u> | <u>Out-of-State Visitor</u> |             |                    |
|--------------------------------------------------------|-----------------------------|-------------|--------------------|
|                                                        | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| No tip paid                                            | 80%                         | 82%         | 79%                |
| Average tip paid (total)                               | \$2.79                      | \$0.82      | \$3.58             |
| Average tip paid (among those<br>paying a tip)         | \$13.71                     | \$4.67      | \$16.72            |
| <br><u>Fish mounting costs</u>                         |                             |             |                    |
| No fish mounting costs                                 | 92%                         | 82%         | 95%                |
| Average fish mount cost (total)                        | \$21.03                     | \$54.82     | \$7.36             |
| Average fish mount cost (among<br>those paying)        | \$248.20                    | \$310.67    | \$154.50           |
| <br>BASE: Total Respondents                            | <br>(59)                    | <br>(17)    | <br>(42)           |



DEMOGRAPHICS

| <u>Sex of Respondent</u>                | <u>Out-of-State Visitor</u> |             |                    |
|-----------------------------------------|-----------------------------|-------------|--------------------|
|                                         | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| Male                                    | 98%                         | 100%        | 98%                |
| Female                                  | 2                           | --          | 2                  |
| <u>Age of Respondent</u>                |                             |             |                    |
| 18-24                                   | 7%                          | 18%         | 2%                 |
| 25-34                                   | 14                          | 6           | 17                 |
| 35-44                                   | 22                          | 6           | 29                 |
| 45-54                                   | 32                          | 47          | 26                 |
| 55-64                                   | 17                          | 12          | 19                 |
| 65 or over                              | 7                           | 6           | 7                  |
| Refused/no response                     | 2                           | 6           | --                 |
| Median age:                             | 46.8                        | 48.0        | 45.9               |
| <u>Occupation of family breadwinner</u> |                             |             |                    |
| Professional/managerial                 | 22%                         | 12%         | 26%                |
| Sales/clerical                          | 22                          | 24          | 21                 |
| Blue Collar                             | 39                          | 47          | 36                 |
| Retired                                 | 8                           | 6           | 10                 |
| Other                                   | 2                           | 6           | --                 |
| Refused/no response                     | 7                           | 6           | 7                  |
| <u>Annual Income</u>                    |                             |             |                    |
| \$15,000 to \$20,000                    | 5%                          | 12%         | 2%                 |
| \$20,000 to \$30,000                    | 7                           | 12          | 5                  |
| \$30,000 to \$40,000                    | 3                           | --          | 5                  |
| More than \$40,000                      | 25                          | 6           | 33                 |
| Refused/no response                     | 59                          | 71          | 55                 |





| <u>Full-Day or Half-Day Charter</u> | <u>Out-of-State Visitor</u> |             |                    |
|-------------------------------------|-----------------------------|-------------|--------------------|
|                                     | <u>Total</u>                | <u>Tour</u> | <u>Independent</u> |
| Full Day                            | 63%                         | 47%         | 69%                |
| Half Day                            | 36                          | 47          | 31                 |
| No response                         | 2                           | 6           | -                  |

Number of Males in Travel Party

|       |     |      |     |
|-------|-----|------|-----|
| One   | 69% | 100% | 57% |
| Two   | 19  | -    | 26  |
| Three | 10  | -    | 14  |
| Five  | 2   | -    | 2   |

Number of Females in Travel Party

|       |     |     |     |
|-------|-----|-----|-----|
| One   | 59% | 94% | 45% |
| Two   | 25  | -   | 36  |
| Three | 10  | 6   | 12  |

Fish Caught

|                                                 |      |      |      |
|-------------------------------------------------|------|------|------|
| Did not catch any fish                          | 63%  | 71%  | 60%  |
| Caught fish                                     | 37   | 29   | 40   |
| Average number fish caught<br>by those catching | 1.6  | 1.7  | 1.5  |
| BASE: Total Respondents                         | (59) | (17) | (42) |



CHARTER FISHING VISITOR  
SURVEY SCREENING SHEET

An important research project is presently being conducted here on the Kona Coast for the National Marine Fisheries Service, and your help in the project would be greatly appreciated.

The Fisheries Service is trying to help our industry by learning more about the social and economic value of commercial and sport fishing. To accomplish this, interviews have already been conducted with charter boat crews and other local fishermen. Now, visitors and local people who charter boats are being interviewed in regard to their reasons for fishing in Kona and their expenditures while here. I'd like to take a few minutes now to ask you about these things.....

A. First, may I ask where you're from?

- (    ) Mainland U.S. (SPECIFY STATE \_\_\_\_\_) Administer  
Out-Of-State
- (    ) Canada (SPECIFY PROVINCE \_\_\_\_\_) → Visitor  
Form
- (    ) Outside U.S. (SPECIFY COUNTRY \_\_\_\_\_) ↑
- 
- (    ) Hawaii -- Another Island (SPECIFY) \_\_\_\_\_ → Administer  
Other Island/Oahu Resident  
Form
- 
- (    ) Big Island \_\_\_\_\_ → Administer  
Big Island  
Form

B. (ASK EVERYONE EXCEPT BIG ISLAND RESIDENTS)

Have your arrangements for this trip to Hawaii been made:

- (    ) Independently (ADMINISTER INDEPENDENT FORM)
- (    ) Through a group tour or package plan (ADMINISTER PACKAGE  
PLAN/ TOUR FORM)



OUT-OF-STATE VISITOR QUESTIONNAIRE  
INDEPENDENT FORM

INTERVIEWER NAME \_\_\_\_\_

BOAT NAME \_\_\_\_\_

DATE \_\_\_\_\_

LOCATION \_\_\_\_\_

RESPONDENT NAME \_\_\_\_\_

HOME ADDRESS OF RESPONDENT

\_\_\_\_\_

\_\_\_\_\_



OUT-OF-STATE VISITOR QUESTIONNAIRE  
INDEPENDENT FORM

Q.1 When did you first consider going deep sea fishing here in Kona? I'll read you some choices.

☐ Before leaving the Mainland or your country of residence.

☐ After arrival on another island in Hawaii (SPECIFY ISLAND \_\_\_\_\_)

☐ After arrival on some other location of the Big Island.

☐ After arrival in Kona. (SKIP TO Q.3)

Q.2 Now I'd like you to assign some percentages to the importance of your deep sea fishing trip to your visit. Deep sea fishing would have a very high percentage importance, for example, if you came to Kona strictly to go deep sea fishing. You should assign a low percentage importance if this fishing trip was incidental to your visit here. Okay, what percentage importance did this deep sea fishing trip have on:

% Importance

a) Your decision to visit the State of Hawaii \_\_\_\_\_

b) Your decision to visit the Big Island \_\_\_\_\_

Q.3 How many people on this fishing trip, including yourself, belong to your immediate travel party?

\_\_\_\_\_

Q.4 Was there anyone in your immediate travel party who did not go fishing on this trip with you?

☐ Yes (ASK....) How many? \_\_\_\_\_

☐ No

Q.5 We'd like to get an idea of the expenditures made by all the people in your immediate travel party for this particular fishing trip. I'll read you a list of expense items. I'd like you to tell me the amount of money you or other people in your travel party spent on each item for your fishing trip today. Don't forget to include all amounts spent in the form of cash, check, or credit card.

| TYPE OF EXPENDITURE                                                      | TOTAL SPENT BY MYSELF AND<br>OTHERS IN MY TRAVEL PARTY |
|--------------------------------------------------------------------------|--------------------------------------------------------|
| Rental fee paid to charter boat operator                                 | \$                                                     |
| Transportation from lodging to boat (if any)                             | \$                                                     |
| Transportation from boat back to lodging (if any)                        | \$                                                     |
| Food and beverages intended for consumption on<br>fishing trip           | \$                                                     |
| Special fishing tackle                                                   | \$                                                     |
| Special apparel, such as hats, gloves, etc.                              | \$                                                     |
| Sundry items, such as suntan lotion, seasick pills,<br>or photo supplies | \$                                                     |
| Other fishing-related expenses (SPECIFY)<br>_____<br>_____               | \$                                                     |





6 Have you already gone on other deep sea fishing trips in Kona during this visit?

( ) No (SKIP TO Q.7)

↓ ( ) Yes

Q.6a. How many times was that? \_\_\_\_\_

7 Do you plan to go deep sea fishing again on this visit to Kona?

( ) No (SKIP TO Q.8)

↓ ( ) Yes

Q.7a. How many times will that be? \_\_\_\_\_

8 (ASK IF RESPONDENT HAS TAKEN OR PLANS TO TAKE OTHER FISHING TRIPS) On these other trips, would you say that your expenses for the charter fishing trip(s) were/will be:

( ) about the same as those of today

( ) more than those of today (HOW MUCH MORE? \_\_\_\_\_)

( ) less than those of today (HOW MUCH LESS? \_\_\_\_\_)

Q.8a. Can you explain why your expenses(were/will be) (more/less) than those of today?

|                                                                                    | Days | Nights |
|------------------------------------------------------------------------------------|------|--------|
| 9 What is the total number of days and nights you've spent so far in Kona?         |      |        |
| 9a. How many more days and nights do you plan to stay in Kona?                     |      |        |
| 10 How many days and nights have you spent so far elsewhere on the Big Island?     |      |        |
| 10a How many more days and nights do you plan to stay elsewhere on the Big Island? |      |        |

11 (ASK THOSE WHO SPENT ALL OF YESTERDAY ON BIG ISLAND.) We're trying to get an idea of how much money in the form of cash, check, or credit card was spent yesterday here on the Big Island by everyone in your travel party. I'll read you another list of expenses which I like you to recall. For some items, such as lodging or car rental, you may have trouble recalling how much you spent yesterday, but know how much the item cost altogether. Just be sure to indicate that you are giving a "total" expense.



Q.11 (continued)

TOTAL SPENT ON BIG ISLAND  
YESTERDAY BY MYSELF AND  
OTHERS IN TRAVEL PARTY

## TYPE OF EXPENDITURE

|                                                                   |             |                                             |
|-------------------------------------------------------------------|-------------|---------------------------------------------|
| Food and beverages, including tips                                |             |                                             |
|                                                                   | Breakfast   | \$                                          |
|                                                                   | Lunch       | \$                                          |
|                                                                   | Dinner      | \$                                          |
|                                                                   | Snacks      | \$                                          |
| Lodging (SPECIFY TYPE)                                            |             |                                             |
| <input type="checkbox"/>                                          | Hotel/Motel | <input type="checkbox"/> Friend or relative |
| <input type="checkbox"/>                                          | Condominium | <input type="checkbox"/> Other              |
| Entertainment and Sightseeing Tours                               |             | \$                                          |
| Car rental, including gas (SPECIFY # DAYS I WILL RENT)            |             | \$                                          |
| Other transportation, such as taxi, bus, and parking              |             | \$                                          |
| Tips to airport and/or hotel personnel                            |             | \$                                          |
| Gifts, souvenirs                                                  |             | \$                                          |
| Clothing                                                          |             | \$                                          |
| Sundry items, such as film, suntan lotion, health and beauty aids |             | \$                                          |
| Any other expenditures (SPECIFY)                                  |             | \$                                          |
|                                                                   |             |                                             |
|                                                                   |             |                                             |

Q.12 Would you say that your expenditures of yesterday were typical of your average daily expenditures (or expected expenditures) while on the Big Island?

( ) Yes (SKIP TO Q.13)

( ) No

Q.12a. Were your expenditures yesterday more or less than your past or anticipated daily expenditures during this stay on the Big Island?

( ) More --- (ASK) How much more? \_\_\_\_\_

( ) Less --- (ASK) How much less? \_\_\_\_\_

Q.12b. Can you explain why yesterday's expenses were (more/less) than your expenses on an average day on this island?

Q.13 Was your airfare or SeaFlite fare to and from this island included with your round trip Hawaii tickets?

( ) Yes (SKIP TO Q.14)

( ) No

Q.13a. How much have you spent or do you expect to spend on airfare or SeaFlite trips to and from this island for everyone in your travel party?

\$ \_\_\_\_\_

Q.13b. How about any airfare or SeaFlite fare for other travel between islands here in Hawaii?



Q.14 How much was spent altogether for airfare for your travel party's round trip tickets to and from the State of Hawaii?

\$ \_\_\_\_\_

Q.14a. How many people age 12 and over did this cover? \_\_\_\_\_

Q.14b. How many children under 12? \_\_\_\_\_

Q.15 What other islands have you visited so far on this trip to Hawaii?

Q.16 What other islands do you intend to visit on this trip?

Q.17 (FOR EACH ISLAND, ASK) How many nights did you stay/do you plan to stay on that island?

| <u>Island</u> | <u>Already Visited</u>   | <u>Plan to Visit</u>     | <u>Number of Nights</u> |
|---------------|--------------------------|--------------------------|-------------------------|
| Oahu          | <input type="checkbox"/> | <input type="checkbox"/> | _____                   |
| Maui          | <input type="checkbox"/> | <input type="checkbox"/> | _____                   |
| Kauai         | <input type="checkbox"/> | <input type="checkbox"/> | _____                   |
| Molokai       | <input type="checkbox"/> | <input type="checkbox"/> | _____                   |

Q.18 Well, we've asked you some detailed questions about your expenditures for fishing and your visit to this island. Now I'd like you to consider the expenses you've incurred or plan to incur for your visits to any other islands on this trip. What proportion of your total expenses does your visit to Kona represent?

\_\_\_\_\_ percent

Q.19 Is this your first visit to the State of Hawaii, or have you been here before?

☐ first visit (SKIP TO Q.20)

↓ ☐ repeat visit

Q.19a. Aside from this trip, how many visits have you made to the State of Hawaii?

\_\_\_\_\_

Q.19b. And how many times did that include a visit to the Big Island?

\_\_\_\_\_

Q.19c. (IF "b" IS ONE OR MORE, ASK) How many times before this visit have you gone fishing here in Kona?

\_\_\_\_\_

Q.20 When do you plan to next visit the State of Hawaii?

\_\_\_\_\_

(IF PLAN TO RETURN, ASK)

Q.20a. Will your next visit include a trip to this island?

↓ ☐ Yes ☐ Maybe  
☐ No (SKIP TO Q.21)

Q.20b. Will you go deep sea fishing here on your next visit to the Big Island?

☐ Yes ☐ Maybe  
☐ No



Q.21 We'd also like to know how you feel about sport fishing in general. How would you rate deep sea fishing on a scale of 1 to 10 in terms of its importance to you as a vacation/leisure activity? You should give it a high rating if sport fishing is very important to you and a low rating if it has little importance as a vacation/leisure time activity.

1 2 3 4 5 6 7 8 9 10

Q.22 Again, on a scale of 1 to 10, how would you rate deep sea fishing in Hawaii compared to fishing in other places you may have visited or have heard about?

1 2 3 4 5 6 7 8 9 10

Q.23 How would you rate deep sea fishing in Kona on a scale of 1 to 10 relative to:

Other activities for visitors here on this island 1 2 3 4 5 6 7 8 9 10

Other activities for visitors in the State of Hawaii 1 2 3 4 5 6 7 8 9 10

We need to ask you some questions about yourself so that we can accurately describe our sample for statistical purposes.

Q.24 How many males are included in your travel party? \_\_\_\_\_

Q.25 How many females? \_\_\_\_\_

Q.26 Please tell me which of the following categories includes your age:

☐ 18 - 24 years

☐ 45 - 54 years

☐ 25 - 34 years

☐ 55 - 64 years

☐ 35 - 44 years

☐ 65 years and over

☐ Refused

Q.27 What is the occupation of your primary family breadwinner?

\_\_\_\_\_

Q.28 Is your yearly household income before taxes:

☐ Under \$20,000

☐ Over \$20,000

is that

☐ Over \$15,000

☐ Over \$30,000

☐ Over \$40,000

☐ Under \$15,000

☐ Under \$30,000

☐ Under \$40,000

My supervisor at Research Associates wants to verify a portion of my work by re-contacting people who have been interviewed. They will be sending postcards to respondents after arrival back on the Mainland. Your participation is, of course, confidential.

May I have your home address in case my supervisors wish to verify this interview? (RECORD NAME AND ADDRESS ON COVER SHEET)

THANK YOU VERY MUCH!!!!!!





## TO BE RECORDED BY INTERVIEWER:

## A. Sex of Respondent

☐ Male☐ Female

## B. Type of fishing trip

☐ Full-day☐ Half-day

## C. Did anyone in the travel party catch a fish?

☐ Yes --- How many? \_\_\_\_\_☐ No

## D. Total tips paid to charter boat operator and crew:

\$ \_\_\_\_\_

## E. (IF APPLICABLE) Total fish mounting costs:

\$ \_\_\_\_\_

## F. OTHER COMMENTS:









**U.S. DEPARTMENT OF COMMERCE**  
**National Oceanic and Atmospheric Administration**  
NATIONAL MARINE FISHERIES SERVICE  
Southwest Fisheries Center  
Honolulu Laboratory  
P. O. Box 3830  
Honolulu, Hawaii 96812

RECENT TRENDS IN THE HAWAII MARKETS  
FOR MAHIMAHI AND ONO

BT and Associates  
516-E Kawaihae Street  
Honolulu, Hawaii 96825

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MAR 1983

A Final Report Fulfilling Requirements of a  
National Marine Fisheries Service Contract  
(Purchase Order No. 82-JJA-00452)

March 1983

NOT FOR PUBLICATION

This report is used to insure prompt dissemination of preliminary results, interim reports, and special studies to the scientific community. Contact the Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service, if you wish to cite or reproduce this material.

## PREFACE

This report was prepared under contract (Purchase Order No. 82-JJA-00452) by BT and Associates of Honolulu, Hawaii. The contract objectives were to document the rising price and demand for mahimahi and ono (wahoo) in Hawaii since 1975 and to comment on the factors which led to this growth. The report represents a unique contribution to understanding the commercial fishery and seafood marketing practices because the personnel involved in BT and Associates are active participants in Hawaii's seafood industry. The auction data also provide an important insight into the relative role of the fresh fish auctions in seafood marketing in Hawaii. Since the report was prepared under contract, the statements, findings, conclusions, and recommendations herein are those of the contractor and do not necessarily reflect the view of the National Marine Fisheries Service.

Samuel G. Pooley  
Industry Economist

March 17, 1983





## 1.0 BACKGROUND AND PURPOSE

BT and Associates was contracted by the Honolulu Laboratory of the National Marine Fisheries Service to conduct a study of recent trends in the marketing of mahimahi and ono in the State of Hawaii. The purpose of the study was threefold:

1. Document the rising price and demand for fresh mahimahi and ono since 1975 using summarized data from the United Fishing Agency, Ltd. (U.F.A.);
2. For the two species, explain the upward trends in demand and price which the data demonstrate; and
3. Determine whether there is any competition between sales of fresh, locally-caught mahimahi and ono, and establish the degree of interaction between sales of fresh mahimahi and imported frozen fillets of this species.

In a letter dated 20 January 1983, Sam Pooley, Industry Economist for the Honolulu Laboratory, requested that several other questions be considered for the final report. To the extent that these questions pertain to marketing, rather than harvesting issues, BT and Associates has attempted to address them in the final report.

## 2.0 METHODS

Except for summarized data obtained from U.F.A., this study relied entirely on interviews. Mr. Frank Goto, General Manager of U.F.A., was interviewed at length, and representatives of the following firms provided valuable information:

### Fish Wholesalers/Retailers

Maeda Fish Market Ltd.  
U. Okada & Company Ltd.  
Wing Sing Corporation  
Ahi Fishing Company Ltd.  
Fishland Market Ltd.  
Wakamatsu Fish Market

Volcano Isle Fish Inc.  
Maui Seafoods  
Tamashiro Market Inc.  
Horimoto Fish Market Inc.  
Tropic Fish & Vegetable Center Inc.

Frozen Food Distributors

Okuhara Foods Inc.  
Young's Meat & Provision Co., Inc.  
A.H. Hansen Sales Ltd.

### 3.0 HISTORICAL TRENDS

#### 3.1 Mahimahi

Relative to other locally-caught species, fresh mahimahi has been a fairly high priced item in Honolulu since at least 1970, when it was served primarily by a few exclusive restaurants. The Willows Restaurant, in particular, was noted for its fresh mahimahi. At that time, mahimahi was more of an incidental catch than a targeted species, so the supply of fresh fish was even more inconsistent than at present.

The principal market for the commercial catch, made by the tuna pole-and-line fleet and tuna longline fleets, was exclusive restaurants, whereas most of the mahimahi taken by recreational trollers was probably used for home consumption. The historical emphasis in the fish marketing sector has been on aku, ahi, and other fishes having red or pink flesh, as these were the preference of the local population who were the major consumers of fresh seafoods. Although the landed price for mahimahi has edged steadily upwards since about 1950, the average price has increased more sharply since about 1973.

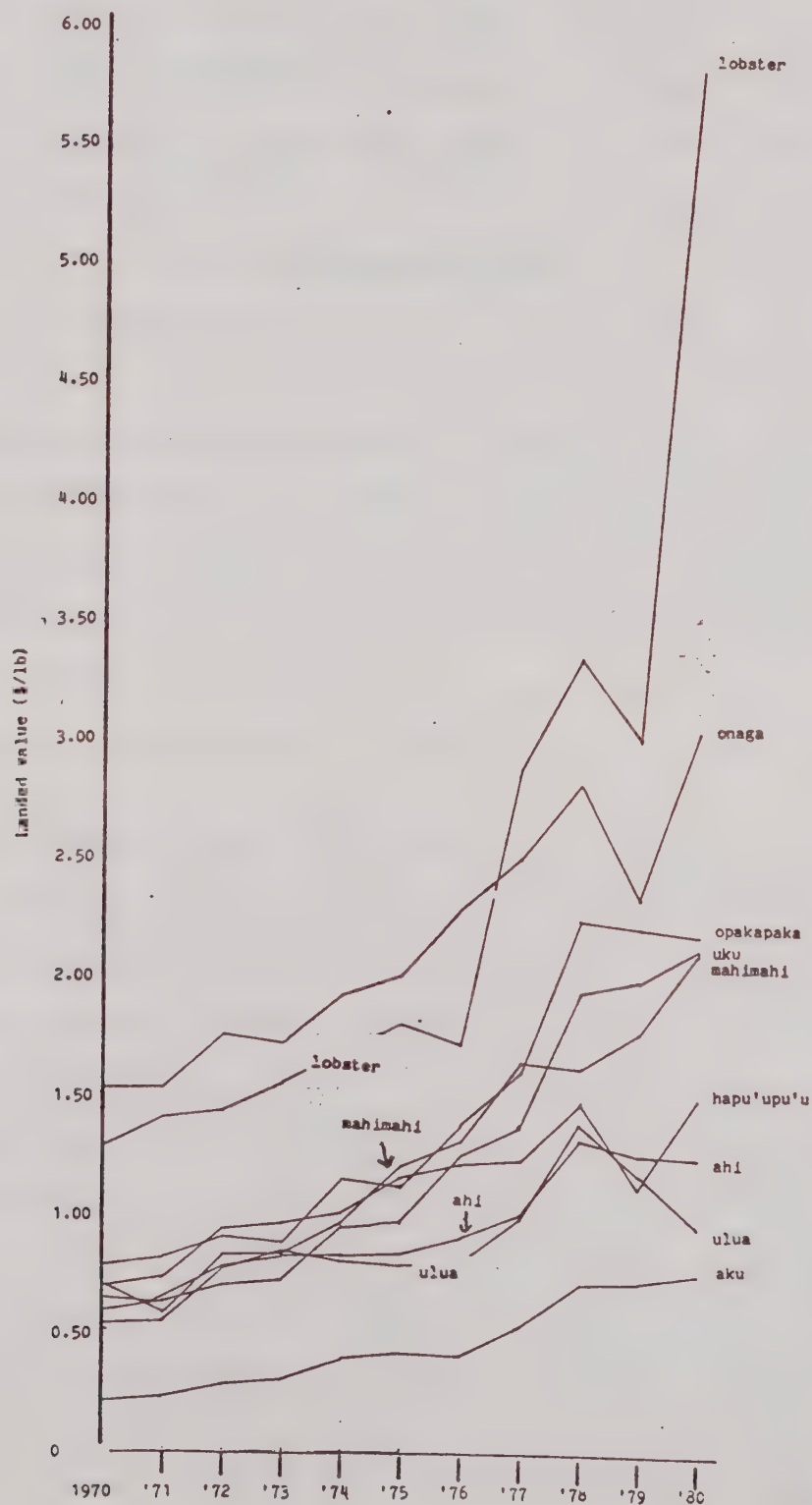
Figure 1 presents a comparison of 1970 to 1980 trends in the average State of Hawaii ex-vessel price for selected species of whole fish and shellfish. The rising price of mahimahi is, over the long term, similar to other white-fleshed fish species, such as opakapaka, uku, and onaga, which are in demand by the same market (i.e., restaurants) which buys most of the mahimahi. The long-term rise in the ex-vessel price for more traditional species, such as aku and ahi, has been more gradual, as indicated by the less steep slopes graphed in Figure 1 for the latter group of species. The difference in price slopes for mahimahi and other white-fleshed species, compared to the more traditional red-fleshed fish, has no doubt caused fishing effort to be spread over a broader resource base in the 1970's than in the previous decade.

### 3.2 Ono

In the early 1970's ono received a lower price and was more of an incidental catch than mahimahi. Like mahimahi, ono was taken by fishermen seeking more valuable red-fleshed species, and a consistent supply was therefore lacking. Unlike mahimahi, which is caught by tuna pole-and-line and longline vessels as well as by trollers, ono is taken predominantly by trolling.

Ono began to be served by restaurants at a much later date than mahimahi. Based on the number of pieces sold through the Honolulu fish auction, ono reached a level of supply and market demand in 1981 equivalent to that of mahimahi in 1976. About 4,300 pieces of ono were sold in 1981, compared to 4,700 pieces of mahimahi sold in 1976. As restaurants become aware of

Figure 1 - 1970-1980 Trends in the Average Ex-vessel Price for Selected Whole Fish and Shellfish Species, State of Hawaii



substitutes for the often limited and high-priced supply of fresh mahimahi, the share of the market captured by ono and equivalent species will increase.

#### 4.0 RECENT TRENDS

##### 4.1 Mahimahi

The price of fresh mahimahi has climbed gradually upwards in recent years. Table 1 documents the increase in average price and fish landings based on a summary of transactions at U.F.A. during the 1975-1981 period. During this period, the average price of mahimahi rose 39%, from \$1.83 per pound to \$2.55 per pound. The total number of fish sold increased 180%, from approximately 4,000 in 1975 to nearly 11,000 in 1981. Total landed weight increased 128%, from 76,000 pounds in 1975 to about 173,000 pounds in 1981. The average weight of fish sold through the auction was somewhat smaller (14-16 pounds) in 1979-1981 period, compared to earlier years (18-20 pounds average). This phenomenon is probably the result of catches of smaller mahimahi by trolling around the fish aggregation devices, first deployed in 1979.

The availability of mahimahi in Hawaiian waters is distinctly seasonal, with peaks in abundance during the spring (March-April) and the fall months (October-November). The small boat operations which characterize the main Hawaiian Islands' fishery are sustained by a diversity of fish resources.

The small boats target seasonally-available resources, such as mahimahi, during periods of maximum abundance but divert



Table 1 - Recent Trends in Annual Mahimahi Transactions  
Through the United Fishing Agency, Ltd.  
Honolulu, Hawaii

|                                  | Y E A R                |                     |                      |                      |                     |                    |                      |
|----------------------------------|------------------------|---------------------|----------------------|----------------------|---------------------|--------------------|----------------------|
|                                  | 1975                   | 1976                | 1977                 | 1978                 | 1979                | 1980               | 1981                 |
| Total number of fish sold        | 3,918                  | 4,754               | 6,145                | 5,328                | 7,814               | 8,687              | 10,957               |
| Month of lowest number           | January                | January             | February             | December             | January             | September          | January              |
| Month of highest number          | April                  | April               | April                | November             | October             | April              | October              |
| Total weight of fish sold (lbs.) | 75,965                 | 96,365              | 110,741              | 97,795               | 112,832             | 142,158            | 173,135              |
| Average weight per fish (lbs.)   | 19.39                  | 20.28               | 18.02                | 18.35                | 14.44               | 16.37              | 15.81                |
| Total sales value (\$)           | \$139,101              | \$190,738           | \$233,441            | \$223,062            | \$242,407           | \$341,653          | \$440,749            |
| Average price per pound (\$/lb.) | \$1.83                 | \$1.98              | \$2.11               | \$2.28               | \$2.15              | \$2.41             | \$2.55               |
| Month of lowest average price    | April/June<br>(\$1.56) | October<br>(\$1.53) | November<br>(\$1.80) | November<br>(\$1.43) | April<br>(\$1.56)   | May<br>(\$1.55)    | April<br>(\$1.94)    |
| Month of highest average price   | July<br>(\$2.80)       | August<br>(\$3.04)  | March<br>(\$3.17)    | December<br>(\$4.60) | January<br>(\$4.95) | August<br>(\$4.55) | February<br>(\$5.12) |

Source: United Fishing Agency, Ltd. records.

fishing efforts during the off-seasons. The smallest number of pieces of fresh mahimahi are sold in the winter months, usually December or January, and the largest number are sold during the spring (usually April) or fall (usually October). Because of the inconsistency in the supply and price of fresh mahimahi, transactions between wholesalers and retailers are on a day-to-day or week-to-week basis, with no formal contracts or purchasing arrangements.

Although mahimahi can be sold for prices of \$4.50-\$5.00 per pound during months of low availability, more important for the long-term income of fishermen is the base level price. In 1981, the average price dropped to only \$1.94 per pound during the months of peak sales, compared to a low monthly price of \$1.55 per pound in earlier years. The U.F.A. data indicate that the demand for fresh mahimahi, as measured by total weight of fish sold, has increased by 128% since 1975, with no indication of softening in the near future. Harvesting of this species continues to be more attractive each year, as indicated by the steady rise in average sales price. Even with rising prices, wholesalers buy all the available mahimahi.

A minimum estimate of the 1981 commercial catch of mahimahi is 239,000 pounds. Only in Hawaii are such large quantities of fresh mahimahi sold, and this species has assumed the position of the unofficial "State fish." The daily auction conducted by the U.F.A. is the principal channel for sales of fresh mahimahi in Hawaii. The price received for fresh mahimahi depends to a great degree upon the demand anticipated by the wholesalers who buy fish through the auction. Because the supply is so uncertain,

the price structure may vary considerably from day to day.

#### 4.2 Ono

The price of fresh ono has climbed sharply in recent years. Table 2 documents this increase based on a summary of transactions at U.F.A. in 1975, compared with those in the 1979-1981 period. The average price of ono rose approximately 200%, from only \$0.67 per pound in 1975, to \$2.06 per pound in 1979. Between 1979 and 1981, the increase moderated, as the average price climbed only from \$2.06 to \$2.46 per pound. The total number of fish sold through the fish auction also increased remarkably between 1975 (about 600 fish) and 1979 (1,900 fish). This sharp rise in total ono landings has continued since 1979 with about 4,300 fish sold in 1981. Total landed weight increased over 400%, from 19,000 pounds in 1975 to over 102,000 pounds in 1981. The auction sales data indicate that catches of ono, and presumably fish effort for this species, are increasing at a more rapid pace than are landings of fresh mahimahi.

Over six times more pieces of mahimahi than ono were sold at the auction in 1975, but by 1981, only 2.5 times more pieces of mahimahi than ono were auctioned. In terms of total revenues, fresh mahimahi sales generated over ten times more income for fishermen than did ono sales in 1975. By 1981, mahimahi sales produced only 1.75 more revenue for fishermen than did ono. The gap between these two species in terms of relative landings and revenues has closed rapidly since the late 1970's. As with mahimahi, the average weight of the ono sold through the auction



Table 2 - Recent Trends in Annual Ono Transactions  
Through the United Fishing Agency, Ltd.  
Honolulu, Hawaii

|                                  | Y E A R  |           |           |           |
|----------------------------------|----------|-----------|-----------|-----------|
|                                  | 1975     | 1979      | 1980      | 1981      |
| Total number of fish sold        | 599      | 1,903     | 3,429     | 4,318     |
| Total weight of fish sold (lbs.) | 19,023   | 50,792    | 85,749    | 102,139   |
| Average weight per fish (lbs.)   | 31.76    | 26.70     | 25.01     | 23.65     |
| Total sales value (\$)           | \$12,782 | \$104,598 | \$183,891 | \$251,097 |
| Average price per pound (\$/lb.) | \$0.67   | \$2.06    | \$2.15    | \$2.46    |

Source: United Fishing Agency, Ltd. records

has been getting smaller in recent years, probably as a consequence of placement of fish aggregation devices. Like mahimahi, the availability, and thus price, of fresh ono is relatively erratic. In Hawaiian waters, ono occurs in maximum abundance during the winter months.

## 5.0 REASONS FOR RECENT TRENDS

### 5.1 Mahimahi

According to the informants, the increasing price and demand for fresh, locally-caught mahimahi result from a combination of circumstances, some of which are local in scale and some of which are nationwide trends:

- \* A general increase in seafood consumption, both in Hawaii and nationwide, due to health conscious consumers.
- \* A growing population of transient and resident Caucasians who are familiar with and have a preference for fresh mahimahi.
- \* The popularity of the "Hawaii" label in mainland U.S. markets.
- \* Convenience in preparation.

#### 5.1.1 Health Concerns

The U.S. population, as a whole, became more health conscious in the 1970's, with more attention given to good diets and exercise. The dietary benefits of eating fish, rather than red meat, became appreciated, and consumer acceptance of seafoods increased throughout the U.S. Consumer appreciation of quality and freshness of fish products grew with the increase in the overall demand for seafood.

### 5.1.2 Familiarity with Fresh Mahimahi

There seems to be a cultural correlation between the ethnic groups which reside in Hawaii and their taste preference in fish. Asian, Hawaiian and other non-Caucasian groups have always had a definite preference for red-fleshed fish whereas Caucasians prefer white-fleshed fish. Prior to 1970, mahimahi was more highly esteemed by resident Caucasians than by other ethnic groups, and with a growing population of mainlanders visiting and moving to Hawaii, the demand for white-fleshed fish grew to a significant level. Prior to this influx of tourists and new residents, the primary consumers of fish were non-Caucasian residents.

Awareness of fish and the seasonal availability of mahimahi in a few restaurants caused greater demand for this species. Primarily as a result of the competitive nature of the restaurant business, fresh mahimahi became established as a menu item among the exclusive restaurants in Honolulu. Tourists and new residents were introduced to other species of white-fleshed fish through their initial experience with fresh mahimahi, supplies of which continued to be inconsistent or seasonal. More people began to prefer and request fresh fish; more restaurants began serving fresh seafood; restaurant chefs learned how to prepare mahimahi according to the taste preferences of tourists; and the fish wholesale and distribution network expanded to provide the fresh product.

The primary market for fresh mahimahi in Hawaii remains in Honolulu, the center of tourism. Although mahimahi sold through the fish auction supplies a large share of this market, some fishing vessels sell directly to wholesalers. The development of an impressive tourist industry on Maui has created a secondary market of considerable proportion for fresh mahimahi. Considering the increase of visitors and the expanding Caucasian resident population on Maui, the per capita consumption of white fish on that island may now be the highest in the State. A rough measure of the extent of the Maui market, compared to Oahu, is the number of seafood restaurants on each island. Honolulu magazine's 1982 restaurant guide lists restaurants on Oahu and on the island of Maui. The Maui market is supplied in large part with mahimahi landed on Oahu.

#### 5.1.3 The "Hawaii" Label

Previous visitors to Hawaii and military personnel have become aware of fresh fish and, upon their return home, advise others about fresh mahimahi. Television and advertising promote the "Hawaii" label on the mainland, and a variety of products, including fresh mahimahi, are marketed under the "made in Hawaii" label. These circumstances have made possible high-priced export markets for fresh mahimahi, as well as establishing a steady clientele of tourists who can appreciate and pay for the fresh product at Hawaii restaurants.

Tourists who are in the fish wholesale or retail business on the West Coast have been sufficiently impressed with mahimahi that, in some instances, they have arranged to import this item

for sale on the mainland. Fresh mahimahi is even shipped to outlets in the U.S. midwest. The availability of mainland outlets allows some of the local mahimahi caught during seasonal peaks in abundance to be shipped out, so that gluts do not greatly depress prices in the local fish market. The percentage of the total mahimahi catch which is exported is certainly no more than 5%, and only the largest wholesalers are involved in export transactions. The price of fresh mahimahi is consistently high, so that it is generally purchased as a restaurant fish. Restaurant demand is so great that little mahimahi is sold over the counter at fish markets or supermarkets.

#### 5.1.4 Convenience in Preparation

The marketing and processing capabilities of the Hawaii fishing industry have expanded significantly since 1975. Fresh mahimahi is routinely filleted for sale to restaurants. The boneless fillets are a highly convenient product form for use by restaurant chefs. The chefs need only cut individual meal sized (6 ounce) portions of fish from the fillets, and this savings in labor is an important economic advantage for the restaurants. Although the yield of saleable product from mahimahi is similar to that from ono, opakapaka and other restaurant species, the body shape and average size of individual fish make it somewhat easier to fillet.

The shelf life of freshly-caught mahimahi is from 5 to 7 days, and most restaurants usually maintain an inventory of mahimahi, which is frozen for short periods. In placing orders



with wholesalers, restaurant purchasing agents have to balance their previous investment in inventory against current availability and price. A restaurant having little inventory may have to pay higher than average prices in order to assure availability of fresh mahimahi. The variability in supply and price, coupled with steady demand, causes the price and also the profit margin of a fresh mahimahi dinner at a Waikiki restaurant to fluctuate considerably throughout the year. Restaurants can list frozen mahimahi dinners on their menus at a fixed price but usually sell fresh mahimahi dinners at a fluctuating price. Some restaurants try to get the maximum from their mahimahi purchases by taking the fish heads for soup stock, but other restaurants do not want the heads.

## 5.2 Frozen Mahimahi Imports

Noting the rising demand for the "State fish" but the lack of a consistent supply, one or two Honolulu wholesalers in 1970-1971 began to make speculative purchases of frozen mahimahi in Japan for import to Hawaii. Mahimahi is not a popular fish in Japan or Taiwan, but it is caught in large quantities by those nations' distant-water tuna longline fleets. Through bulk purchasing, the Honolulu buyers were able to obtain low prices and uniformity of the frozen product in filleted form.

The availability of a consistent supply of frozen fillets made it possible for exclusive restaurants to back up the limited fresh fish supply and to print mahimahi on the menus with assurance. The low cost of the frozen imported product gave fast-food and general public restaurants the opportunity to serve

mahimahi as a low budget menu item. The only way to provide every tourist with the experience of eating the best known fish in Hawaii is through frozen fillets. Although frozen fillets are sold through retail markets, they are most widely used by the large number of restaurants which serve the general public, rather than an exclusive clientele. Two relatively independent markets--differentiated by their demand for fresh or frozen mahimahi--have thus developed. There is little, if any, competition between the two product forms because of major differences in both quality and price. The declared value of frozen mahimahi imports from Taiwan and Japan averaged \$0.76 per pound in 1980, compared to an average sales price of \$2.41 per pound for fresh mahimahi sold through the fish auction. Although a few 50-pound cases of frozen mahimahi fillets are transshipped to the U.S. mainland each year, the imported fish is, for the most part, consumed in Hawaii.

Imports of frozen mahimahi fillets totalled an estimated 6 million pounds in 1980, compared to an average of 2.6 million pounds per year prior to 1975. The quantity and value of mahimahi imports are estimated in Table 3 for the 1972-1981 period. Taiwan supplies most of the imports. Smaller quantities are shipped from Japan, and some mahimahi fillets originate in Latin America and are shipped directly from Ecuador or are transhipped to Hawaii through Los Angeles. During the summer months, Hawaii distributors rely on large seasonal catches of fillets imported in frozen form from Taiwan and Japan. The Latin America fillets augment the reduced supply from Asian nations during the winter.

Table 3 - Weight and Value of Frozen Mahimahi Fillets Imported to Hawaii,  
by Country of Origin, 1972 - 1980

| YEAR | COUNTRY OF ORIGIN      |                    |                        |                    |                        |                    | TOTAL                  |                    |
|------|------------------------|--------------------|------------------------|--------------------|------------------------|--------------------|------------------------|--------------------|
|      | Taiwan                 |                    | Japan                  |                    | Ecuador                |                    |                        |                    |
|      | Weight<br>(1,000 lbs.) | Value<br>(\$1,000) | Weight<br>(1,000 lbs.) | Value<br>(\$1,000) | Weight<br>(1,000 lbs.) | Value<br>(\$1,000) | Weight<br>(1,000 lbs.) | Value<br>(\$1,000) |
| 1972 | 1,620                  | 977                | 661                    | 392                | N.A.                   | N.A.               | 2,281                  | 1,369              |
| 1973 | 2,541                  | 1,052              | 153                    | 67                 | N.A.                   | N.A.               | 2,694                  | 1,119              |
| 1974 | 1,406                  | 842                | 439                    | 271                | N.A.                   | N.A.               | 1,845                  | 1,113              |
| 1975 | 2,098                  | 1,927              | 680                    | 526                | N.A.                   | N.A.               | 2,778                  | 2,453              |
| 1976 | 1,876                  | 1,411              | 394                    | 280                | N.A.                   | N.A.               | 2,270                  | 1,691              |
| 1977 | 2,750                  | 2,020              | 382                    | 253                | N.A.                   | N.A.               | 3,132                  | 2,273              |
| 1978 | 3,385                  | 2,203              | 202                    | 146                | 200                    | 124                | 3,787                  | 2,473              |
| 1979 | 4,147                  | 2,745              | 177                    | 131                | 183                    | 107                | 4,507                  | 2,983              |
| 1980 | 3,767                  | 2,844              | 368                    | 299                | N.A.                   | N.A.               | 4,135                  | 3,143              |

Note: N.A. = not available

Source: IA 254, U.S. Imports for Consumption and General Imports, District 32, Custom District by Country of Origin by TSUA Number by Unit Control and Method of Transportation, Foreign Trade Division, Bureau of the Census, Department of Commerce.



Taiwanese mahimahi is considered to have better quality than that from other sources, and wholesalers generally consider purchases from Latin America only when the Taiwanese product cannot be obtained (Evering, 1980).

Mahimahi is shipped to Hawaii as frozen, skin-on, boneless, trimmed fillets, which are often graded and priced by weight gradations. In the initial years of import, wholesalers could purchase the frozen fillets for about \$0.30 per pound, but in recent years, the price has been \$0.75-0.80 per pound. Retailers pay about \$1.00-1.20 per pound. In recent years, approximately 7 major wholesalers and many more smaller wholesalers have been involved in importing mahimahi from Taiwan. A standard order from one wholesaler would be one container load (30,000 pounds) per month. Several of the large wholesalers occasionally bought directly from Taiwanese export firms, but most used a broker who combined orders. The Taiwanese fillets are distributed directly to retailers, whereas the fillets from Latin America arrive in larger lots (250,000 pounds) and are frequently held in storage and withdrawn when supply is short. Three or four large shipments are purchased each year directly from Latin America fish dealers or through New York brokers.

In April 1979, a case of histamine (scombroid) poisoning in Hawaii was attributed to a mahimahi fillet from Taiwan. The U.S. Food and Drug Administration (FDA) delayed the sale of approximately 25% of incoming shipments of frozen mahimahi until tests were made. Histamines are difficult to detect because their presence is far from uniform in batches of fish. The risk of histamine poisoning is greatly increased by poor handling of

mahimahi by exporters. In the summer and fall of 1980, several more incidents of histamine poisoning occurred, and every container of frozen fillets was blocklisted by the FDA, which means that all shipments into the U.S. are automatically detained until the importer can prove that it conforms to required standards by means of laboratory analysis of samples. There is no discrimination between mahimahi fillets from various origins. Although the testing of samples can be completed within a few days after seizure, the FDA takes months to review the laboratory results and complete the paperwork necessary to release the frozen fish for sale. Not only are distributors' initial costs for fish purchases tied up, but storage fees are incurred during the delays. The cost of the delay, plus the loss of several lots of the product, rejected by the FDA, caused an outflux of dealers handling mahimahi imports in Hawaii. There was a reduction in imports from Taiwan and Japan in 1980, possibly caused by the confusion in the market. The reduction forced some buyers to accept New Zealand snapper fillets as a substitute for mahimahi in the spring of 1981 (Evering, 1980).

Frozen mahimahi is becoming a more expensive source of protein, because the extra cost of meeting quality standards, as well as the cost of the FDA delays in releasing the product for sale, are being passed on to consumers. Nevertheless, there does not appear to be a slackening of demand for this product. Because of the major differences in the price for fresh and frozen mahimahi, the fast-food and general public restaurants which are the major buyers of the frozen fillets are not generally able to

substitute fresh mahimahi if their frozen supply is interrupted.

### 5.3 Fresh Ono

Comparison of Table 2 with Table 1 indicates that the gap in total landings and revenues which existed between fresh mahimahi and fresh ono as recently as 1975 is closing rapidly. The explanation for the sharp rise in the demand and price for ono is that it has been perceived as a close equivalent to mahimahi by the restaurants which serve fresh white-fleshed fish and has found market acceptance. The supply of locally-caught mahimahi is highly seasonal and extremely limited considering the high demand for this fish. It is not possible for restaurants to offer fresh mahimahi throughout the year, and chefs have looked to other white-fleshed fish, including ono and opakapaka, as substitutes. Unlike mahimahi, the other species are not available in frozen form as a back-up to the fresh product. Therefore, ono, opakapaka, ulua, swordfish, and other species which complement or substitute for the more popular mahimahi are generally served as "fish of the day" or as specials. The price of a fresh ono dinner at one popular restaurant has increased from \$7.50 to \$12 over the past four years.

All of the white meat species upon which restaurants rely are subject to seasonal limits in availability, so it is necessary for chefs to rely on the full array. Their purchases are based on the affordability, as well as the availability, of the preferred species. The restaurant demand for white meat fishes is too great to be satisfied by the combination of fresh mahimahi and ono and their seasonal abundance in Hawaiian waters

does not greatly overlap, so there is no competition between the species.

Ono (wahoo) is not as widely available in the world's oceans as is mahimahi so no system has developed to import a frozen product to Hawaii. Ono is sometimes imported to the U.S. from India and other parts of Asia as frozen steaks or fillets, but is not available in steady supply.

## 6.0 CONCLUSIONS

The rising demand for locally-caught, fresh mahimahi is a result of acceptance among the Caucasian tourist and resident populations of Hawaii, and the strong association of this species with the "Hawaii" label. The shift toward greater seafood consumption among a health-conscious American population has contributed to greater awareness and preference for fresh seafoods in general.

The great demand in restaurants for fresh mahimahi, coupled with the relatively low supply, has raised the price significantly, causing an increase in fishing effort for this species. The bulk of the fast-food and general public restaurants in Hawaii cannot afford to put high-priced fresh mahimahi on their menus, but large imports of frozen mahimahi fillets have made low-budget meals feasible for such establishments. The fresh and frozen products each have their own niches, and the difference in price and quality keep both niches available. The relatively independent markets cannot do without either product form.

Fresh ono is rapidly gaining the same market acceptance and status as fresh mahimahi in the restaurants which serve white meat fish to tourists. The supply of fresh ono is as limited as that of fresh mahimahi, and the price of both will continue to climb as long as the tourist experience in Hawaii includes a fresh fish dinner. In fact, market opportunities may exist for other white meat species if they could gain market recognition and acceptance comparable to mahimahi and ono.



It should be remembered that the demand for fresh mahimahi, ono, and other white meat species is strongly correlated with the success of the tourist industry in Hawaii. A decline in that industry could have major repercussions on the market situation, and it may be advisable for the private sector to have a contingency plan for such an occurrence.

#### REFERENCES CITED

- Evering, G.C., 1980. The supply of Coryphaena hippurus in the State of Hawaii. Unpub. student paper for Ag. Econ. 431 (The Economics of Fisheries and Aquaculture), University of Hawaii, 18 p.











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**National Oceanic and Atmospheric Administration**  
NATIONAL MARINE FISHERIES SERVICE  
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OPERATIONS AND PROCEDURES MANUAL FOR VISITING SCIENTISTS  
AT THE KEWALO RESEARCH FACILITY

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## INTRODUCTION

The Kewalo Research Facility (KRF) is part of the Southwest Fisheries Center's Honolulu Laboratory. The KRF is the only research facility in the world that maintains stocks of live tuna specifically for behavioral and physiological research, and it has been the site of active tuna research for 25 years. The KRF has hosted visiting scientists since its inception. This booklet is designed to orient prospective and visiting researchers to various aspects of working with tunas and to list certain obligations that must be fulfilled by visiting scientists.

Before work can begin a proposal must be submitted for review and approval to Mr. Richard S. Shomura, Laboratory Director, Dr. Richard W. Brill, Leader, Experimental Ecology of Tunas Program; and Mr. Randolph K. C. Chang, KRF Manager. The proposal should include a background discussion of the intended work, tentative procedures, fish and laboratory requirements (including space, equipment, and personnel), and the expected duration of the visit. The desired starting dates should also be stated, keeping in mind that the availability of tunas at the KRF is not the same year-round.

Also, there are forms that must be completed before work at KRF can begin. These will be sent upon approval of the initial proposal.

## FACILITIES

The following accommodations (Figure 1) are available to visiting scientists at the KRF: 1) Office space (usually limited to a small work area with a desk), 2) the RV Kaahale'ale (a 33-ft research vessel outfitted for inshore ocean work, available only on a short-term basis), 3) holding and experimental tanks (tank space is limited but some flexibility is possible; however, Honolulu Laboratory research projects must have first priority).

The KRF is an excellent place for marine research. The seawater supplied to the holding tanks is filtered through crushed coral. It is therefore free of most fouling organisms and the water quality is well within levels set by the Environmental Protection Agency (Table 1). Holding tanks (Figure 1) are 8 and 6 m in diameter above ground pools and a large concrete oceanarium (20 × 15 × 3.3 m deep). Seawater is supplied to the pools at a flow rate sufficient to turn over the volume in the tanks in approximately 24 h. There are also three observation towers situated near the holding tanks.

## AVAILABILITY OF LIVE TUNAS

The KRF routinely maintains three species of live tunas: skipjack tuna, Katsuwonus pelamis; yellowfin tuna (ahi), Thunnus albacares; kawakawa, Euthynnus affinis; and occasionally bigeye tuna, T. obesus. In addition, dolphinfish (mahimahi), Coryphaena hippurus, are being cultured at the KRF and at several other institutions in Hawaii. These fish are therefore available as research subjects as eggs, larvae, juveniles, or adults.



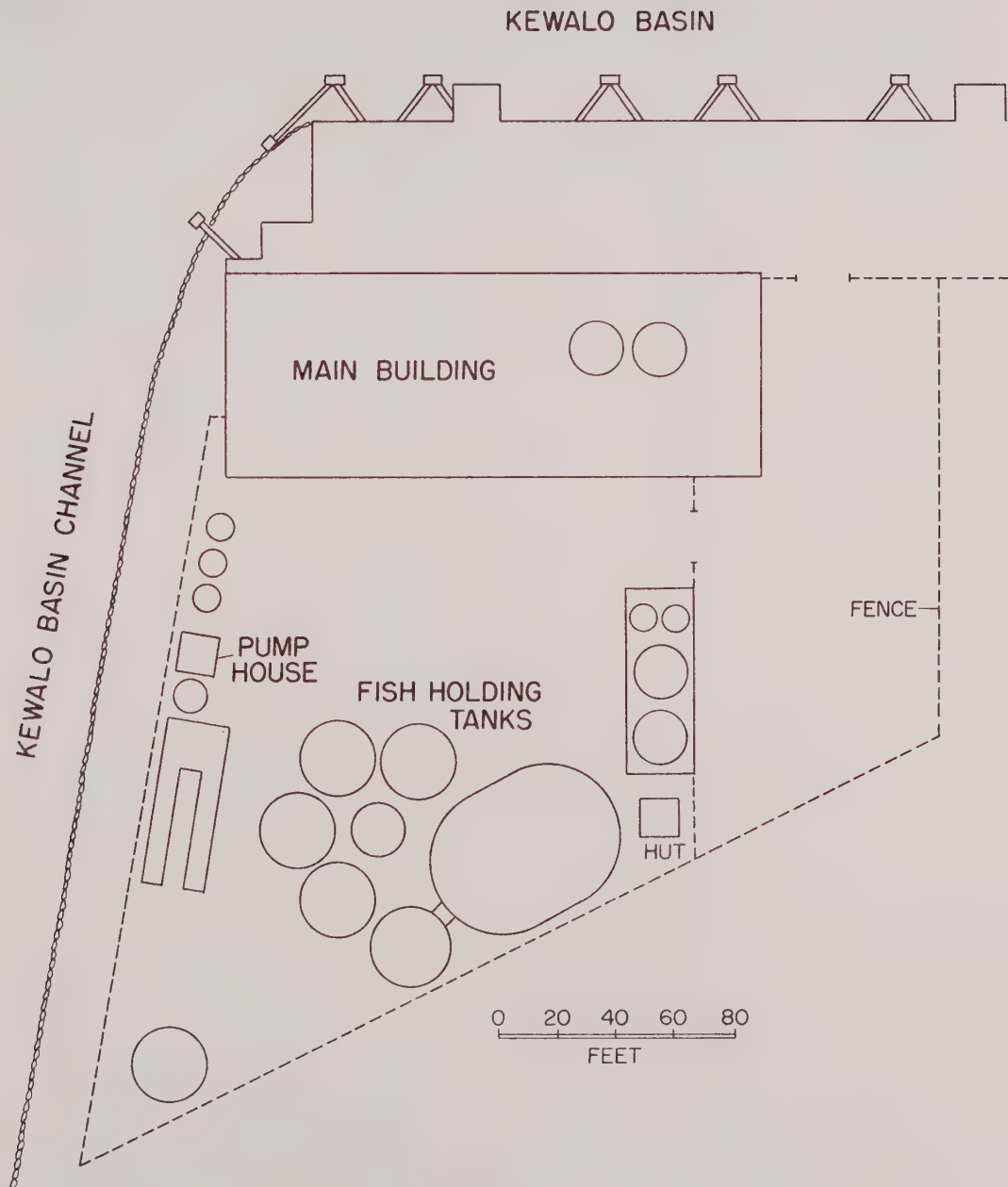


Figure 1.--Schematic map of the Kewalo Research Facility. Offices and laboratories are in the main building.





Table 1.--Analysis results of seawater from well at Kewalo Research Facility.

| Contents                    | KRF well | Standard seawater | Units |
|-----------------------------|----------|-------------------|-------|
| Salinity S <sup>o</sup> /oo | 34.566   | 35.0              | o/oo  |
| Cl                          | 20,050   | 19,353            | mg/l  |
| Ca                          | 392      | 411               | mg/l  |
| Mg                          | 1,300    | 1,293             | mg/l  |
| Na                          | 11,300   | 10,762            | mg/l  |
| K                           | 400      | 399               | mg/l  |
| Si                          | 9        | --                | mg/l  |
|                             |          | Safe levels*      |       |
| Pb                          | <0.6     | 50                | μg/l  |
| Cu                          | 0.46     | 50                | μg/l  |
| Zn**                        | 135      | 4                 | μg/l  |
| Mn                          | 18       | 100               | μg/l  |
| Fe                          | 0.61     | 1                 | mg/l  |
| Cr                          | 1.6      | 100               | μg/l  |
| Cd                          | <0.01    | 1.2               | μg/l  |

\*As established by the Environmental Protection Agency.

\*\*Zn values may be due to laboratory error.



The availability of live tunas at KRF is not the same year-round and this must be considered when scheduling a research project. There are a number of reasons why the fish may be unavailable. However, the seasonal commercial value of the tunas is the overriding factor. The commercial tuna fishing boats, locally referred to as aku boats, are the only suppliers of live tuna and it is only through their voluntary cooperation that we receive animals. The fishermen are paid for the fish that are delivered to the KRF, but they receive only a fraction of the amount that they can usually get in the market. This is especially true around the holidays (December-January).

Figure 2 shows the monthly average number of skipjack tuna, yellowfin tuna, and kawakawa delivered to the KRF over a 5-year period (1977-81). These graphs do not take into account whether fish were on order, nor are they an indication of availability of fish to the commercial fishery. (Note: Kawakawa have little market value and they are not generally sought by the aku boats.) These graphs are intended to show when research time might be optimally scheduled. For example, a researcher intending to use skipjack tuna in late winter may spend long periods of time waiting for fish.

Once the KRF Manager is aware of a researcher's need for fish he informs the tuna boat liaison, Mr. Shoji Teramoto, who in turn contacts the aku boat captains. If fishing for market-sized fish is slow, captains will look for schools of small tuna for the KRF. Although tuna of a specific size can be requested, delivery cannot be guaranteed. The normal price for a load of live tuna (12-25 fish) is \$300. The price for dead specimens is usually the market price (\$50 for 10, for example). These prices are subject to change.

Figure 3 gives the fork-length frequency distribution for the tunas available at the KRF during 1981 and 1982. The relatively narrow size range available is due to the fact that tuna with fork lengths of 29 to 49 cm (approximately 0.5 to 2 kg body weight) have the best survival rates during capture and delivery operations.

Capture and delivery procedures are as follows. A feeding school of tuna is attracted to the boat by chumming with live bait and the tuna are caught on feather jigs with barbless hooks. The fish are then literally tossed into baitwells that have been flooded with seawater. When a sufficient number have been caught the boat returns to the KRF. News of their catch is received well in advance via radio and Mr. Teramoto is there to meet the boat with a transfer tank.

When the fishermen arrive at a dock near the KRF they offload the fish into a transfer tank. Chamois nets are used to get the fish out of the baitwells. The soft nets help to prevent eye and skin damage. The researcher may be present at the transfer, especially if there is some procedure that needs to be done shortly after the fish arrive. The transfer tank is then moved to the appropriate holding tank. At this point the fish are released by lowering the entire transfer tank into the holding tank. One edge of the transfer tank is lowered allowing the fish to swim out. Handling, while unavoidable, is kept to a minimum to avoid unnecessary injury to the fish.



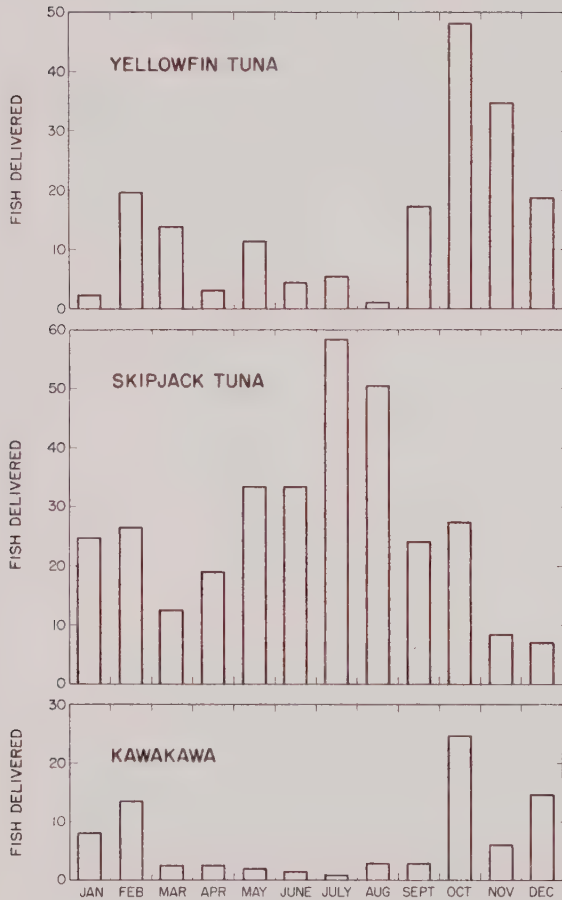


Figure 2.--Average number of tunas (by species) delivered to the Kewalo Research Facility over a 5-year period (1977-81). Skipjack tuna are the most readily available species. Kawakawa are not routinely sought by the commercial fishing boats that supply tuna to the Kewalo Research Facility and a special order must be placed.

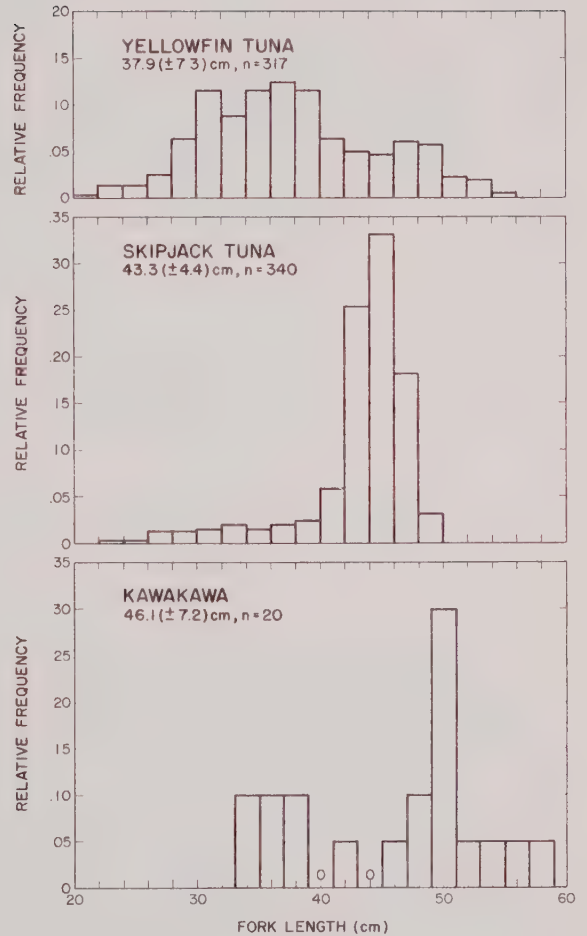


Figure 3.--Size-frequency distribution for the species of tunas routinely available at the Kewalo Research Facility (1981-82). Tunas greater than 50-60 cm fork length rarely survive capture and delivery operations, although larger tunas are commercially caught around Oahu, Hawaii.



It is the responsibility of each researcher to see that tank space has been reserved for incoming fish. This is done at the weekly staff meeting.

#### CAPTIVITY PROBLEMS

The condition of the tuna at the time of arrival at the KRF holding tanks depends on a number of uncontrollable factors. Severe hook wounds, skin abrasions, and frayed fins are common and unavoidable during capture. The only surface a tuna "knows" is the interface between the sea and air. The walls of the tuna boat's baitwells are new and stressful, and if rough seas are added to crowded baitwell conditions, tunas with normally excellent avoidance responses may literally bounce off the walls.

Mortality statistics collected at KRF reveal the following:

- 1) Mortality in a delivery of fish may be from 0 to 100%.
- 2) Most mortalities occur on the second or third day after capture (Figure 4).
- 3) Many mortalities can be attributed to severe hook wounds and/or skin abrasions which appear to cause death either through osmotic imbalance or infection.

Each species of tuna has its own problems in captivity. Skipjack tuna are the most fragile and can be kept healthy for only a relatively short time. They are easily acclimated to captivity and usually feed readily but are subject to a condition known as puffy snout. All tunas are susceptible to puffy snout, which is probably stress related, but skipjack tuna are the most severely affected in the shortest period of time. Puffy snout is a deformation of the skull into pillowy looking blisters (Figure 5). Fish with severe puffy snout die from starvation because the blisters eventually cover the teeth and occlude the eyes and prevent the fish from feeding. A number of studies have been conducted to determine the cause of puffy snout, but no conclusive factor has been found. Puffy snout usually occurs within the first few weeks of captivity in most skipjack tuna.

It is often difficult to get yellowfin tuna to start feeding. Once they begin to feed, however, they do well. As an example, yellowfin tuna were maintained at KRF over 3 years and grew to weigh over 45 kg (100 lb). Yellowfin tuna may jump out of the holding tanks and are especially prone to do this during feeding. Puffy snout is only a slight problem. Mortalities of yellowfin tuna kept for extended periods of time are probably due to dietary deficiencies.

Kawakawa do very well in captivity and are prone to only minor puffy snout problems. They have also been kept at the KRF for as long as 3 years but their growth in captivity is not as dramatic as that of yellowfin tuna.





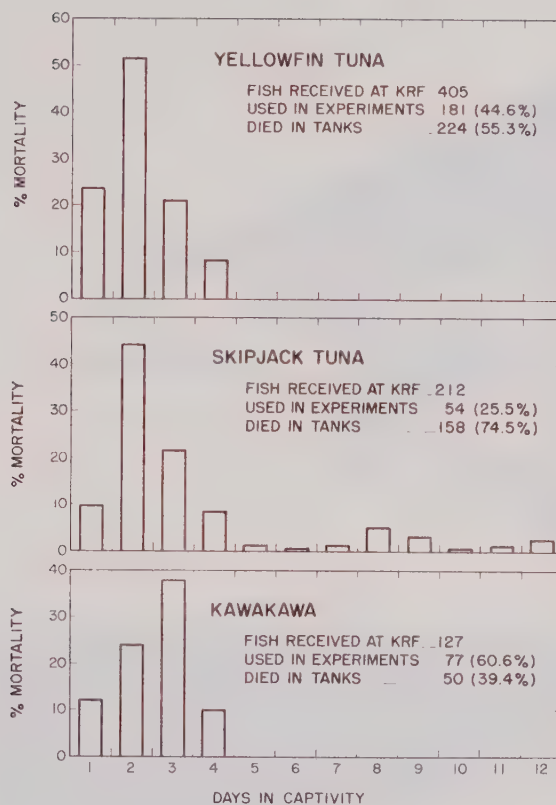


Figure 4.--Daily mortalities expressed as the fraction of fish dying before they can be used as experimental subjects (1980-81). After heavy mortalities on days 2 and 3, usually due to capture trauma, survival rates increase. Note: Data past day 4 for kawakawa and yellowfin tuna are available but now shown.





Figure 5.--Normal skipjack tuna (upper) and a skipjack tuna with advanced puffy snout. This condition can occur within weeks in captivity. The teeth and eyes are affected by puffy snout. Fish with severe puffy snout cannot feed and eventually die of starvation.



Fish will usually begin to feed by the second week of their captivity, but there is no set pattern. If fish do not feed by this time, starvation becomes a primary cause of mortality. The KRF keeps a supply of krill and nehu (Hawaiian anchovy, Stolephorus purpureus) to entice newly captured fish to feed. Yellowfin tuna often respond to krill first, whereas skipjack tuna will often begin feeding on nehu. Initially, feeding attempts must be made at least three times a day by throwing a few pieces of food in front of the school while splashing the water. (We humans suppose that this simulates a bait school.) Once one fish in a tank shows interest in feeding, the rest usually follow. It is also easier to get new fish feeding if there is an acclimated fish already in the tank. After fish get accustomed to food that no longer swims, daily feedings of thawed frozen foods begin.

Established fish are fed once a day until satiated. Tuna will often jump during feeding as the food hits the surface and will also smash into the sides of a tank in an effort to get food. For these reasons food must be thrown towards the center of the tank and away from the walls. An interesting aspect of tuna's feeding behavior is the appearance of vertical bars on the sides of the fish. These are quite striking in skipjack tuna and show up to a lesser degree in the other species.

Diets can be varied according to the needs of the researcher and his funding. Providing a diet that is closest to that of a wild fish is possible but expensive, because the food must be purchased at retail market prices. The KRF keeps a supply of frozen smelt, krill, and squid for daily feedings.

Once in the tanks the fish show behavioral characteristics that are similar to those of fish in the wild. Healthy, unstressed fish will begin schooling soon after being put into the holding tanks. One sign of fish in distress is a break in the schooling pattern. An unhealthy individual will swim independently of the school.

#### HANDLING PROCEDURES FOR BEHAVIORAL EXPERIMENTS

Tuna, as experimental animals, can be both incredibly fragile and unbelievably tough. They may survive a drop on the floor only to die due to a seemingly minor bump on the snout. They must always be handled as carefully and as gently as possible.

In transferring fish to be used in behavioral experiments the equipment developed by Dr. Calvin M. Kaya for spawning studies is used (Figure 6). The water level in the tank is lowered and an individual fish is separated from the school. Using a small seine, the fish is channeled into a large funnel that forces it to swim into a plastic sac (Figure 7). The sac containing the fish is handed out of the tank and literally run to its new destination. When working with fish in the holding tanks it is important to keep the uninvolved fish moving and away from nets and transfer equipment. Tunas must continuously swim to pass water over their gills and time spent immobile can cause severe hypoxia. Healthy tuna have a good avoidance response but in a crowded situation panic may override this.



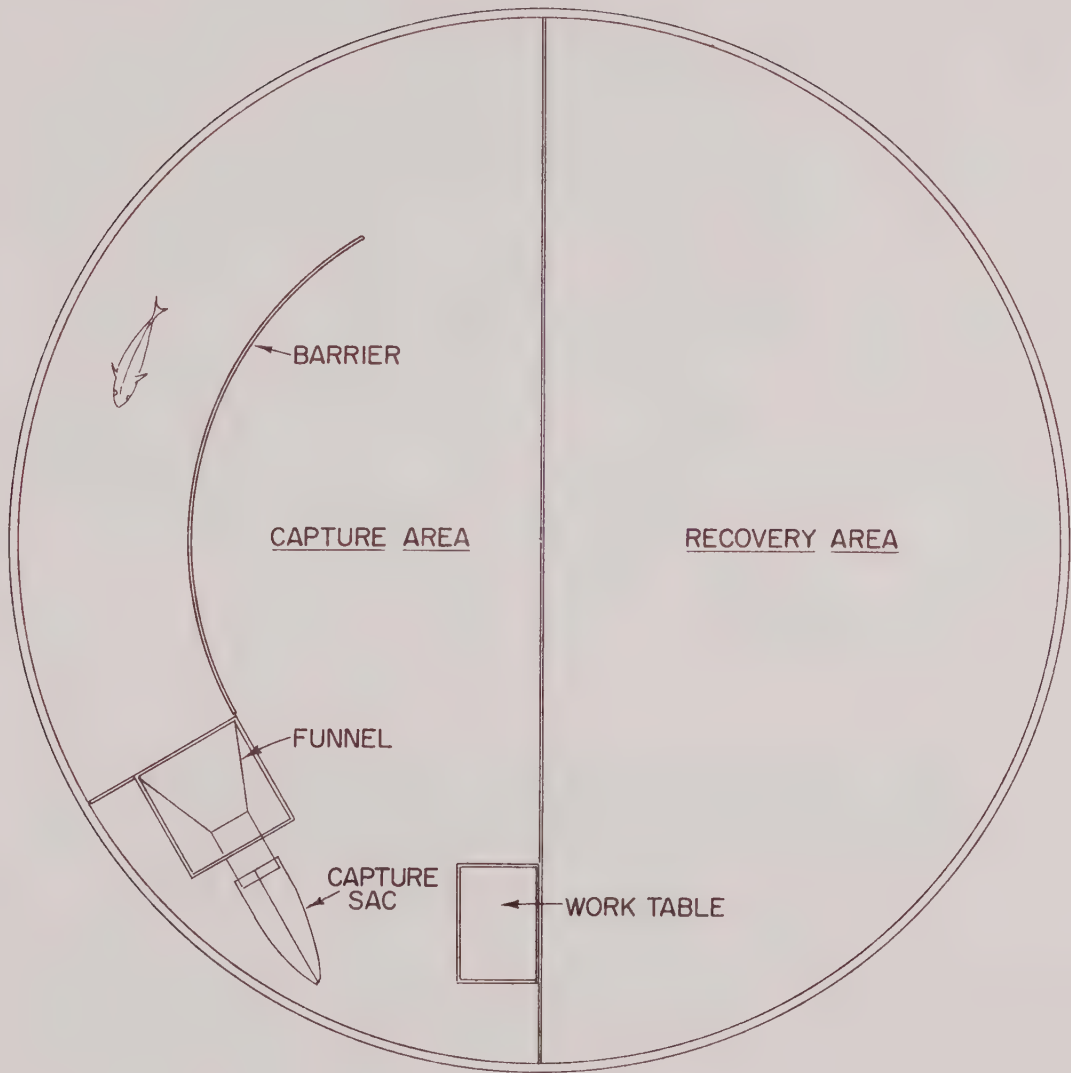


Figure 6.--A fish holding tank with capture system installed. Fish are channeled in the capture sac. At this point they can be transferred to the desired work site or put on the work table (see Figure 8) for taking biopsies or injecting drugs. Figure is from C. M. Kaya, M. K. K. Queenth, and A. E. Dizon, "A capturing and restraining technique for the gonadal biopsy, injection, and marking of small tuna in laboratory holding tanks." (Manuscript in preparation.)





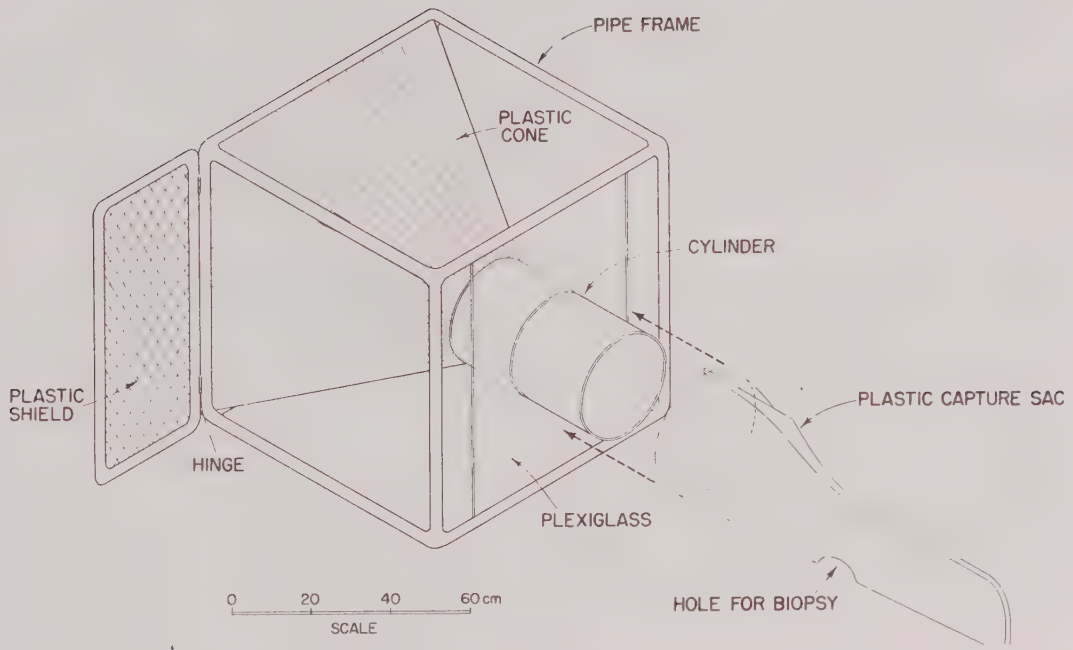


Figure 7.--Plastic funnel and capture sac. Figure is from C. M. Kaya, M. K. K. Queenth, and A. E. Dizon, "A capturing and restraining technique for the gonadal biopsy, injection, and marking of small tuna in laboratory holding tanks." (Manuscript in preparation.)

Behavioral work done at the KRF often requires a tuna to perform a task in response to a stimulus. Tunas learn fairly rapidly although their repertoire of responses is limited to activities that can be performed while moving. As an example, tunas can be trained to swim through a hoop or tunnel initially using bait to induce the fish to respond in the desired fashion. After a number of trials the fish will usually begin to respond freely.

Skipjack tuna are the most difficult to train primarily because their activity level is high and the period of time that they stay healthy is short. Yellowfin tuna are the easiest to train and they become almost petlike in their ability to perform. Kawakawa are also easily trained although they are so motivated by the food reward that they must often be fed first to slow down their activity.



## HANDLING PROCEDURES FOR PHYSIOLOGICAL EXPERIMENTS

To obtain fish from the holding tanks that are to be used in acute physiological experiments, a large crowder net and a scoop net will suffice. These fish are not usually expected to perform or recover. Again, the fish that will be used in the experiment must be carefully isolated from the rest of the school. After a fish has been netted it may be injected with an anesthetic or paralytic agent and returned to a holding tank until the drug takes effect.

Both bath and injectable anesthetics have been tried but there are a number of disadvantages to the former. Large amounts of bath type drugs must be used in the volume of water that is needed for a swimming tuna. This makes such drugs as MS 222 and quinaldine impractical. These anesthetics also tend to irritate the gills which cause the fish to become overly excited and the tunas tend to smash into the tank walls before the drug can take effect. Drugs given in the food may or may not work as the fish will often reject the drugged bait. The most often used procedure for administering drugs is injection, but it also has some drawbacks. With intramuscular injections the drug may be pushed back out the injection site by muscular contractions, resulting in a reduced dosage. Intravenous injections are not practical because neither the ventral aorta nor caudal vein can be easily entered in a struggling tuna. Intraperitoneal injection is also difficult in a struggling fish.

Once on the operating table, the fish's gills are irrigated with oxygenated seawater and the fish is confined within a padded plexiglass trough to minimize struggling. Fish have survived up to 8 h in this situation and can be used in neurophysiological, cardiovascular, or other types of physiological experiments.

If biopsies or carefully placed injections are necessary there is a restraining table (Figure 8) that can be used within the holding tanks. The fish is captured using the previously described funnel device and plastic sac and then placed on the foam padded table while it is still in the plastic carrying sac. The fish can then be tightly restrained while biopsies are taken or injections given.

## GENERAL PROCEDURES

There are some general procedures that should be followed by visiting researchers at KRF. The staff will be able to provide some assistance, but this is limited and visiting researchers are expected to do the following:

- 1) Take care of research animals if they require any specialized maintenance other than routine daily feeding and tank cleaning. Tank cleaning must be done every 2 or 3 days. The primary fouling organism is a brown diatom that proliferates on the walls and bottoms of the tanks. Time permitting, the KRF staff will assist with tank cleaning.



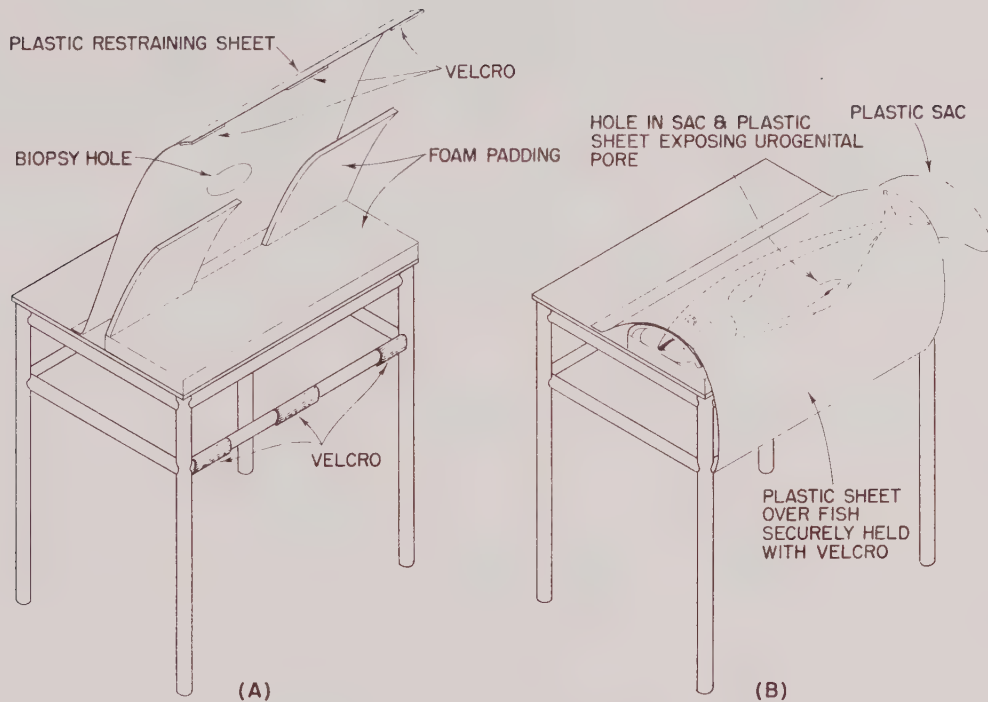
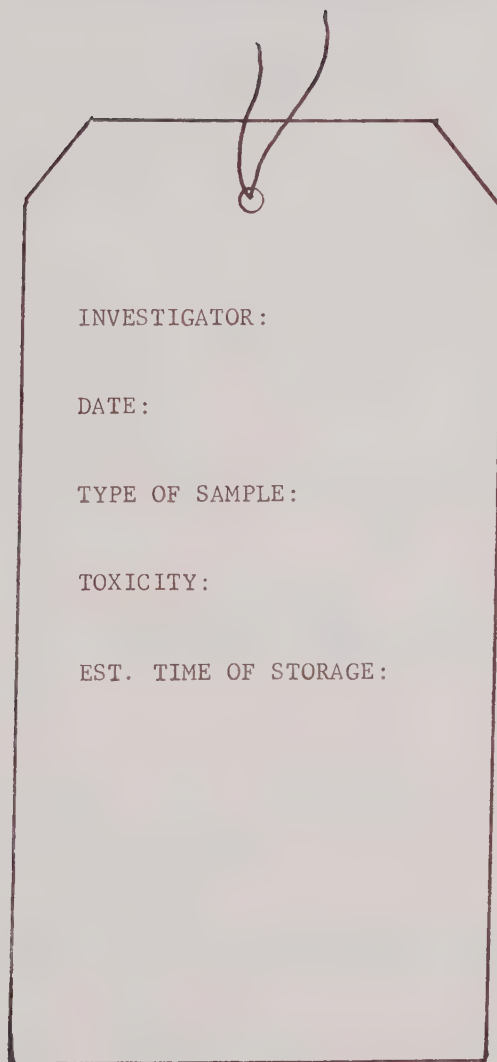


Figure 8.--Restraining table used for taking biopsies or injecting drugs. When this table is used in conjunction with the capture system shown in Figure 6, injection or biopsy procedures can often be done repeatedly. Figure is from C. M. Kaya, M. K. Queen, and A. E. Dizon, "A capturing and restraining technique for the gonadal biopsy, injection, and marking of small tuna in laboratory holding tanks." (Manuscript in preparation.)

- 2) Maintain a clean and orderly work area.
- 3) Use appropriate safety equipment when using any power tools.
- 4) Label (Figure 9) and store all specimens in the appropriate storage areas.
- 5) Keep track of all specifically assigned animals by filling out a mortality log (Figure 10).
- 6) Attend KRF staff meetings each Monday at noon. At this time all researchers must be prepared to discuss requirements for the upcoming week such as fish, tank space, etc., and to give a brief summary of the past week's progress. The meetings are informal, but follow a set agenda. The minutes are posted after each meeting.





INVESTIGATOR:

DATE:

TYPE OF SAMPLE:

TOXICITY:

EST. TIME OF STORAGE:

Figure 9.--Standard sample label to be used on all specimens and hazardous chemicals stored at the Kewalo Research Facility.





NATIONAL MARINE FISHERIES SERVICE  
SOUTHWEST FISHERIES CENTER  
HONOLULU LABORATORY

FISH MORTALITY LOG

Tank GIVE DESIGNATED TANK NUMBER

Species SJ/ YF/ KK Date of death \_\_\_\_\_

Date of capture \_\_\_\_\_ IF KNOWN

Sex \_\_\_\_\_ Male \_\_\_\_\_ g Fork length \_\_\_\_\_ cm - TIP OF NOSE  
USUALLY Female \_\_\_\_\_ g Weight \_\_\_\_\_ g TO FORK OF TAIL  
DETERMINED  
FOR SJ, KK Not determined \_\_\_\_\_

Cause of death \_\_\_\_\_ Handling \_\_\_\_\_  
\_\_\_\_\_ Used in experiment LIST RESEARCHER AND EXPERIMENT TITLE  
\_\_\_\_\_ Starved \_\_\_\_\_  
\_\_\_\_\_ Unknown OR OTHER \_\_\_\_\_

Puffy snout \_\_\_\_\_ Yes STATE DEGREE (MODERATE, BAD, EYES OCCLUDED)  
\_\_\_\_\_ No

Autopsy:

(1) Hook wounds \_\_\_\_\_ Upper \_\_\_\_\_ STATE DEGREE  
\_\_\_\_\_ Lower \_\_\_\_\_  
\_\_\_\_\_ Not applicable

(2) Frayed fins \_\_\_\_\_ Yes DETAILS  
\_\_\_\_\_ No S

(3) Bruises \_\_\_\_\_ Yes DETAILS  
\_\_\_\_\_ No

(4) Eye damage \_\_\_\_\_ Yes DETAILS  
\_\_\_\_\_ No

(5) Gross anatomy LIST ANY DETAILS THAT ARE OF INTEREST OR THAT MAY HAVE  
CONTRIBUTED TO THE ANIMAL'S DEATH.

Figure 10.--Sample mortality log. One of these logs must be filled out for every fish removed from a holding tank.



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ASSESSMENT OF THE STOCK OF GREEN TURTLES NESTING AT  
EAST ISLAND, FRENCH FRIGATE SHOALS

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## INTRODUCTION

This report assesses the status of green turtles, Chelonia mydas, nesting at East Island, French Frigate Shoals, a key breeding ground of this species in the Hawaiian Archipelago. Although observations of green turtle occurrence and habits have been recorded throughout the Hawaiian Islands over many years, for the most part these are sporadic and unsuitable for a rigorous quantitative analysis. However, at East Island, Balazs (1980 and elsewhere) has studied the turtle population intensively since 1973. His studies have ranged over many aspects of green turtle biology and ecology, and his observations provide a reasonably solid basis for partial assessment of the East Island stock. The analysis reported here, relying entirely on Balazs' data over the period 1973-82, focuses specifically on the dynamics of the nesting females. Males are not considered, nor are immature animals. The primary questions posed are:

- How large is the stock of mature females in the East Island colony?
- How many of these can be expected to be nesting in any year?
- How many females reach maturity each year, i.e., how many recruits (neophytes) are added to the population each year?
- What can be said about trends in these variables over recent years?

The following sections describe the models and methods used, indicate the data sources employed, and present the basic findings relative to the major questions. While many of the key assumptions are discussed, some of the more obvious ones are omitted. Further, mathematical details are not given and many of the finer analytical points are glossed over; these will be the subject of another report.



## MODELS AND METHODS

## Basic Population Model

To evaluate changes in the number of nesting females on East Island, we first need a conceptual model which relates the actual number of females observed nesting there each year to the basic underlying population processes. The model used here states that the number of nesters during the current season depends on four factors:

(1) The sequence of recruitments of first-time nesters joining the mature female population. One such year class is added each year;

(2) the probabilities that members of each existing year class will still be alive during the current breeding season (survival rates);

(3) the probabilities that survivors from each year class will actually be hauling out to nest at sometime during the current breeding season (remigration probabilities); and

(4) the probability that any turtle hauling out to nest during the current season will be observed and counted during the specified survey period on East Island (coverage rate).

For this analysis there were 10 basic observations, i.e., each year's sample count of nesting females during 1973-82. Unfortunately, the number of unknown parameters greatly exceeded 10, so some simplifying assumptions were required and some of the parameters had to be estimated from other data.



## Analytical Procedure

Specifically, the following approach was adopted:

(1) Coverage rates and estimated nesting populations.---Coverage rates for each year were estimated from a stochastic model of turtle residence at East Island. The model is based on probability distributions for (a) the within-season time of arrival and commencement of nesting activity for individual females, (b) the number of nesting episodes (potential clutches of eggs deposited) per female, (c) the time interval between successive nesting episodes (during these intervals a female is temporarily absent from the nesting population), and (d) the duration of each nesting episode. A nesting episode is defined as the sum of nocturnal activity of hauling out and digging associated with the laying of a particular clutch of eggs, or the ultimately unsuccessful attempts to deposit the eggs.

Each of these probability distributions was estimated empirically using Balazs' detailed observations for the 1974 and 1975 breeding seasons. Assuming the same distributions were applicable to each year 1973-82, the coverage rate for a specified year was estimated, given the survey period (or set of periods) for that year. The coverage rates were then divided into the actual counts of turtles nesting during the survey periods to estimate the total numbers of turtles nesting during the full breeding seasons.

(2) Annual survival rates and remigration rates.---Annual survival rate for mature females was assumed to be constant during 1977-82, and this rate, together with two parameters of a theoretical probability distribution of remigration intervals, were then estimated from tag





recapture statistics gathered by Balazs during this 6-year period. The analysis was based on the numbers of turtles resighted on East Island during the survey periods of 1978-82 from cohorts of nesting females tagged during the 1977-81 seasons (Table 1). The observed numbers of recaptures each year were adjusted upward to correct for tag shedding (Table 2; tag shedding probabilities were estimated from double-tagging data), and were increased further by applying the appropriate coverage rates.

The theoretical remigration model assumed that during any breeding season the probability that a mature female hauls out to nest depends only on the number of years elapsed since her last nesting, and that this probability increases asymptotically from some minimum value for an interval of 1 year to unity as the time interval increases.

When survival rate and remigration parameters were estimated jointly and no constraints were placed on the estimation, the analysis suggested a high survival rate. However, because the estimates of survival rate and remigration parameters are statistically confounded in the tag recapture model, they are not as reliable as we might like. Accordingly, three different sets of remigration parameters were computed, each conditional on a different assumed level of annual survival during the 1977-82 period when the tagged females were at large. In each case the combination of survival rate and remigration parameters was consistent with the adjusted tag resighting data.

(3) Annual recruitment.--Annual recruitment to the mature female population was assumed to be a function of time. The form of the relationship depends on a set of coefficients estimated from the sequence



of adjusted annual counts of nesting females, and a matrix of "contribution" factors computed from survival and remigration probabilities. Estimating a single coefficient in this model is equivalent to assuming constant recruitment; the estimate of the coefficient is the estimate of this constant recruitment level. Estimating two coefficients is equivalent to assuming a linear trend in recruitment during the relevant time period; the estimates of the coefficients indicate the time-specific values of recruitment and, most important, the direction of the assumed trend. Models with three or more coefficients could be fit to the data, but with only 10 years of observations in the analysis, the higher-order recruitment functions are not informative.

In computing the "contribution" factors, we considered two kinds of scenarios regarding survival rates among adult females: (a) Annual survival rate was constant over all relevant years at one of the three levels assumed in estimating remigration rates, and (b) annual survival rate was lower in the years prior to 1978, when the harvesting of green turtles was outlawed. For each of the three levels of survival rate assumed above for the 1978-82 period, three lower levels of constant annual survival rate were assumed to apply during the pre-ban period.

A total of 12 scenarios resulted from this scheme, defined as follows:



| <u>Scenario</u> | <u>Annual survival rate (%)</u> |                 |
|-----------------|---------------------------------|-----------------|
|                 | <u>Pre-ban</u>                  | <u>Post-ban</u> |
| 1               | 95                              | 95              |
| 2               | 90                              | 90              |
| 3               | 80                              | 80              |
| 4               | 90                              | 95              |
| 5               | 80                              | 95              |
| 6               | 70                              | 95              |
| 7               | 85                              | 90              |
| 8               | 75                              | 90              |
| 9               | 65                              | 90              |
| 10              | 75                              | 80              |
| 11              | 65                              | 80              |
| 12              | 55                              | 80              |

For each scenario, recruitment coefficients were estimated, average recruitment level was determined and the trend in recruitment was assessed.

(4) Population size.--The estimates of annual recruitment were combined with assumed survival rates to compute, for each scenario, the average number of mature females in the East Island population during both the pre-ban and post-ban periods.

## RESULTS

### Coverage Rates and Estimated Nesting Populations

Coverage rates ranged from 25% in 1977 to 84% in 1974 (Table 3). These were applied to the observed number of turtles nesting during the survey periods to estimate the total yearly nesting populations (Table 3 and Figure 1). Nesting populations varied from 81 in 1973 to 220 in 1981, and showed an increasing trend during the 10-year period. The average annual nesting population increased from 126 turtles during 1973-77 to 161 during the following 5-year period. However, the increase in size of the nesting population is not statistically significant.



### Survival Rate and Remigration Parameters

The estimates of remigration parameters were relatively insensitive to the assumed annual survival rate during the tag-recapture period. Regardless of whether survival rate was assumed to be 95, 90, or 80%, the probability that a nesting female will, if still live, nest again during the following breeding season was judged to be virtually nil (Table 4). The probability of nesting increases each year thereafter as the "dormant" years accumulate, as shown for a representative case in Figure 2. The associated probability distribution of the remigration interval for this case is shown in Figure 3. In all three cases examined, the most frequent interval between breeding seasons for a female was 3 years (34-37%), followed by 2 years (28-34%), and 4 years (20-23%). The average remigration interval is about 3 years (Table 4).

Considering both survival rates and the sequence of annual nesting probabilities associated with any particular female's mature life, the average female with a possible mature life of 20 years will remigrate an average of 3.8 times if annual survival is 95%, 2.4 times if survival is 90%, and only once if annual survival rate is 80% (Table 4). The chances of remigrating at least once are 86, 74, and 51%, respectively. When survival rate is 95% each year, the most probable number of remigrations during a mature female's life is 6, followed by 7, then 1, 5, 2, 3, 4, 8, and 9. These distributions change markedly with changes in basic remigration parameters and survival rates (Table 4).





## Recruitment

Estimates of the average annual recruitment of neophytes to the nesting population at East Island range from 30 turtles under the uniformly high survival rate of scenario 1, to 104 turtles under scenario 12 (Table 5). As expected, the recruitment estimates are inversely related to the assumed average survival rate. The actual average recruitment is probably between 40 and 70 turtles per year.

In 11 of the 12 scenarios, the estimated trend in recruitment over the relevant time period (mid-1960's through 1982) was upward. This result is not necessarily expected. The total nesting population was judged to be increasing over 1973-82, and such a trend might be attributed either to increasing survival rates or to greater recruitments, or both. However, in each scenario the increasing trend in recruitment was statistically insignificant, and the hypothesis of constant recruitment could not be rejected. This was especially so for those scenarios which assumed a dramatic increase in survival; only when a constant survival rate was assumed did the upward trend in recruitment approach significance. Because the two factors are highly confounded, without some independent measures of survival rates or recruitment it will be difficult to evaluate trends in the nesting population.

## Population Size

Estimates of the total number of mature females in the East Island population, averaged over 1973-77 and 1978-82, are given in Table 6. In the scenarios with constant survival rate and steady recruitment, population size is also constant, and is estimated to be between about 360



and 400 turtles. Estimates computed under other scenarios are not very useful, because neither the increases in nesting population nor the estimated upward trend in recruitment were statistically significant.

### Steady State Characteristics

Assuming constant annual recruitment, we can compute a variety of steady state characteristics of the mature female population under the fixed survival rate scenarios. In particular, it may be shown, using the statistics in Tables 4 and 7, that the expected egg and hatchling production by a single female over her entire mature life is equal to the total annual egg and hatchling production per recruit. Maintenance of this hypothetical equilibrium would require total survival rates from hatchling (entering sea) to neophyte nesters ranging from about 0.4% under scenario 1 to 1.0% under scenario 3. Given an average nesting population of 144 turtles, together with the estimated average recruitment and total mature female population, we can compute the expected number of veteran females in the population and the number of remigrants nesting each year (Table 7). Depending on the assumed survival rate for mature females, the fraction of veterans remigrating each year ranges from 25 to 31%. Under the 80% survival rate, 50% of the nesting population each year would be neophytes. If annual survival rate is 95%, this figure is reduced to 21%.

### SUMMARY AND CONCLUSIONS

The average nesting population at East Island during 1973-82 was 144 turtles. There was an upward trend in the yearly number of nesters, but this was not statistically significant.



The average number of neophyte turtles recruiting to the mature female population each year was estimated to be between 30 and 72, depending on the assumed adult female survival rate. The corresponding range in the estimated average total population of mature females was from 397 to 358 turtles. Apparent upward trends in recruitment and the total female population were also statistically insignificant.

Assessment of the adult female stock is complicated by several factors:

(1) While the analysis of tag recapture statistics indicated that annual survival of adult females is high, survival rate and remigration parameters are highly confounded in the estimation model. As a result, a unique and reliable estimate of survival rate was not possible, and further analyses were carried out conditionally, given a variety of assumed survival scenarios.

(2) In the analysis of recruitment and total mature female population, results were weakened by the confounding of survival rate and recruitment, and the absence of a reliable, independent estimate of the survival rate.

(3) In estimating the total nesting population each year, sample counts made during the limited survey periods were adjusted upwards to correct for incomplete coverage. The estimated coverage rates were based on the assumption that the distributions of arrival time, internesting interval, and other factors were the same each year as they were in 1974 and 1975. The same assumption was necessary when the coverage rates were applied to the tag recapture data. Year-to-year variation in the overall residence time distribution could alter the results substantially.



At this juncture, it is apparent that a definitive understanding of the population dynamics of mature females in the East Island breeding colony would require some independent determination of either survival rate or recruitment. Of these, only recruitment could be estimated directly. This would require intensive "saturation tagging" of the entire nesting population each breeding season for many years, and the counting of all untagged and unscarred turtles arriving to nest each year. This is an approach used in other green turtle colonies where access costs are much lower than in the Northwestern Hawaiian Islands. Complete censuses of this type also obviate the need for coverage rate adjustments.

If the primary assessment strategy is to judge the trends in the East Island nesting population on the basis of sample surveys, more work should be done to bolster our understanding of variations in the arrival time distribution and other factors affecting coverage rate. In addition, other types of assessment techniques should be investigated, possibly involving observations on basking turtles as well as nesters. Balazs' excellent program of tagging and recapture should be continued.

Extrapolation of the findings for the mature female population at East Island to other segments of the turtle stock, or to other islands, should obviously be done circumspectly. Balazs estimates that the East Island nesters make up roughly 55% of all females nesting at French Frigate Shoals. On the average, the total nesting female population at French Frigate might then be on the order of 300 turtles, of which perhaps 80-100 are neophytes and the remainder remigrants. The total mature female population associated with French Frigate Shoals is probably about 750 turtles. Speculating further, each year roughly 100 of these die.





With assumptions on sex ratios and comparative survival rates, estimates of the adult male population could be generated based on the figures for females. Alternatively, independent estimates for males might be feasible from analysis of tag returns and basking data, but this seems unlikely.

The analysis here excluded consideration of some major phases in the life cycle. For example, all events associated with the immature stages, and with the "dormant" periods for mature females, were conspicuously neglected. The simple stock-and-recruitment approach adopted treats these other phases as a black box whose inner workings are poorly understood or unimportant. At best, this focusing of attention on the inputs (recruits) and outputs (egg production) of the nesting female population might lead eventually to a predictive relationship between the two variables, as in salmon management. At least, it permits a rough monitoring of the stock. But a genuine understanding of turtle ecology and population dynamics, and the capacity to reliably evaluate management policies, will clearly require concentrated and expensive research on other life stages as well.

#### LITERATURE CITED

Balazs, George H.

1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-7, 141 p.



Table 1.--Numbers of nesting females tagged on East Island and sighted as remigrants in subsequent years. Data from G. Balazs.

Yearly data

| Year of tagging | Number nesting females tagged | Year of resighting |      |      |      |      |
|-----------------|-------------------------------|--------------------|------|------|------|------|
|                 |                               | 1978               | 1979 | 1980 | 1981 | 1982 |
| 1977            | 38                            | 0                  | 9    | 8    | 6    | 1    |
| 1978            | 52                            | --                 | 0    | 3    | 18   | 6    |
| 1979            | 52                            | --                 | --   | 0    | 13   | 13   |
| 1980            | 45                            | --                 | --   | --   | 0    | 15   |
| 1981            | 120                           | --                 | --   | --   | --   | 1    |

Aggregate data

| Years after tagging | Total initial release | Total tagged females resighted |
|---------------------|-----------------------|--------------------------------|
| 1                   | 307                   | 1                              |
| 2                   | 187                   | 40                             |
| 3                   | 142                   | 39                             |
| 4                   | 90                    | 12                             |
| 5                   | 38                    | 1                              |



Table 2.--Estimated average probabilities of tag retention (at least one tag still attached) for nesting females tagged and resighted at East Island. Based on double-tagging data collected by G. Balazs.

| Year of<br>tagging | Year of resighting |      |      |      |      |
|--------------------|--------------------|------|------|------|------|
|                    | 1978               | 1979 | 1980 | 1981 | 1982 |
| 1977               | 0.99               | 0.97 | 0.95 | 0.92 | 0.89 |
| 1978               | --                 | 0.97 | 0.94 | 0.90 | 0.87 |
| 1979               | --                 | --   | 0.98 | 0.96 | 0.94 |
| 1980               | --                 | --   | --   | 0.98 | 0.96 |
| 1981               | --                 | --   | --   | --   | 0.99 |



Table 3.--Dates of surveys of nesting female population at East Island, number of turtles seen during these periods, estimated coverage rates, and estimated total nesting populations. Based on data of G. Balazs.

| Year | Period | Survey dates |         | Number<br>of nights | Estimated<br>coverage<br>rate | Number of<br>turtles seen | Estimated<br>nesting<br>population |
|------|--------|--------------|---------|---------------------|-------------------------------|---------------------------|------------------------------------|
|      |        | From         | To      |                     |                               |                           |                                    |
| 1973 | 1      | 1 June       | 19 July | 43                  | 0.81                          | 66                        | 81                                 |
| 1974 | 1      | 1 June       | 19 July | 19                  | 0.84                          | 104                       | 124                                |
|      | 2      | 27 June      | 17 July | 21                  |                               |                           |                                    |
|      | 3      | 27 July      | 14 Aug. | 19                  |                               |                           |                                    |
| 1975 | 1      | 21 May       | 21 May  | 1                   | 0.65                          | 104                       | 161                                |
|      | 2      | 6 June       | 24 June | 19                  |                               |                           |                                    |
|      | 3      | 19 July      | 27 July | 19                  |                               |                           |                                    |
| 1976 | 1      | 28 June      | 11 July | 14                  | 0.32                          | 28                        | 88                                 |
| 1977 | 1      | 24 June      | 2 July  | 9                   | 0.25                          | 44                        | 175                                |
| 1978 | 1      | 9 June       | 19 June | 11                  | 0.39                          | 66                        | 167                                |
| 1979 | 1      | 16 June      | 28 June | 13                  | 0.40                          | 55                        | 136                                |
| 1980 | 1      | 10 June      | 29 June | 20                  | 0.54                          | 45                        | 84                                 |
| 1981 | 1      | 26 May       | 17 June | 23                  | 0.58                          | 127                       | 220                                |
| 1982 | 1      | 6 June       | 24 June | 19                  | 0.56                          | 111                       | 199                                |





Table 4.--Various characteristics of hypothetical steady state East Island green turtle population, under three different scenarios. Sources: (1) Assumed value; (2) Estimated by author; (3) Estimated by G. Balazs; (4) Combination of (2) and (3).

| Characteristic                                                    | Source | Scenario |        |        |
|-------------------------------------------------------------------|--------|----------|--------|--------|
|                                                                   |        | 1        | 2      | 3      |
| • Annual instantaneous mortality rate                             | 1      | 0.05     | 0.10   | 0.22   |
| • Annual survival rate (%)                                        | 1      | 95       | 90     | 80     |
| • Remigration parameter $\alpha$                                  | 2      | 0.4182   | 0.3863 | 0.3308 |
| • Remigration parameter $\theta$                                  | 2      | 0.9931   | 0.9926 | 0.9912 |
| • Average remigration interval (years)                            | 2      | 3.0      | 3.1    | 3.2    |
| • Probability distribution of remigration interval (%)            | 2      |          |        |        |
| 1 year                                                            |        | 0.7      | 0.7    | 0.9    |
| 2 years                                                           |        | 34.4     | 32.3   | 28.5   |
| 3 years                                                           |        | 37.0     | 36.3   | 34.5   |
| 4 years                                                           |        | 20.0     | 21.1   | 22.8   |
| 5 years                                                           |        | 6.4      | 7.5    | 9.8    |
| 6 years                                                           |        | 1.3      | 1.7    | 2.8    |
| 7 years                                                           |        | 0.2      | 0.3    | 0.6    |
| 8 years                                                           |        | 0.0      | 0.0    | 0.1    |
| • Probability of remigrating at lease once during mature life (%) | 2      | 86       | 74     | 51     |
| • Probability of never remigrating (%)                            | 2      | 14       | 26     | 49     |
| • Probability distribution of number of remigrations (%)          | 2      |          |        |        |
| 1 time                                                            |        | 12.0     | 19.3   | 25.0   |
| 2 times                                                           |        | 10.3     | 14.3   | 12.6   |
| 3 times                                                           |        | 8.9      | 10.5   | 6.4    |
| 4 times                                                           |        | 8.0      | 8.0    | 3.3    |
| 5 times                                                           |        | 11.5     | 7.8    | 1.8    |
| 6 times                                                           |        | 18.7     | 8.3    | 1.0    |
| 7 times                                                           |        | 13.3     | 4.5    | 0.3    |
| 8 times                                                           |        | 3.2      | 0.9    | 0.0    |
| 9 times                                                           |        | 0.2      | 0.0    | 0.0    |
| 10 times                                                          |        | 0.0      | 0.0    | 0.0    |
| • Average number of remigrations                                  | 2      | 3.8      | 2.4    | 1.0    |
| • Average number of reproductive seasons                          | 2      | 4.8      | 3.4    | 2.0    |
| • Average number of egg clutches per season                       | 3      | 1.8      | 1.8    | 1.8    |
| • Average number of eggs per clutch                               | 3      | 104      | 104    | 104    |
| • Total egg production during life                                | 4      | 898      | 636    | 374    |
| • Probability of hatching (%)                                     | 3      | 77       | 77     | 77     |
| • Probability of emerging (%)                                     | 3      | 71       | 71     | 71     |
| • Probability of surviving scramble to sea (%)                    | 3      | 95       | 95     | 95     |
| • Total hatchlings entering sea                                   | 4      | 466      | 330    | 194    |
| • Total female hatchlings entering sea (50:50 sex ratio)          | 4      | 233      | 165    | 97     |
| • Precruit replacement survival rate (%)                          | 4      | 0.43     | 0.61   | 1.03   |



Table 5.--Estimated average annual recruitments to nesting female population at East Island under different survival scenarios, sign of estimated trend in recruitment and statistical significance of trend (n.s. = not significant, m = marginally significant at 10% significance level). Based on data of G. Balazs.

| Scenario | Survival rate (%) |          | Estimated average recruitment | Sign of trend | Significance of trend |
|----------|-------------------|----------|-------------------------------|---------------|-----------------------|
|          | Pre-ban           | Post-ban |                               |               |                       |
| 1        | 95                | 95       | 30                            | +             | m                     |
| 2        | 90                | 90       | 43                            | +             | m                     |
| 3        | 80                | 80       | 72                            | +             | m                     |
| 4        | 95                | 90       | 41                            | +             | m                     |
| 5        | 95                | 80       | 60                            | +             | n.s.                  |
| 6        | 95                | 70       | 74                            | -             | n.s.                  |
| 7        | 90                | 85       | 54                            | +             | m                     |
| 8        | 90                | 75       | 72                            | +             | n.s.                  |
| 9        | 90                | 65       | 85                            | +             | n.s.                  |
| 10       | 80                | 75       | 82                            | +             | m                     |
| 11       | 80                | 65       | 95                            | +             | n.s.                  |
| 12       | 80                | 55       | 104                           | +             | n.s.                  |



Table 6.--Estimated average mature female population during two time periods, under two recruitment assumptions and 12 survival scenarios. Based on data of G. Balazs.

| Scenario | Constant recruitment<br>Average mature female<br>population |         | Linear recruitment<br>Average mature female<br>population |         |
|----------|-------------------------------------------------------------|---------|-----------------------------------------------------------|---------|
|          | 1973-77                                                     | 1978-82 | 1973-77                                                   | 1978-82 |
| 1        | 397                                                         | 397     | 317                                                       | 441     |
| 2        | 387                                                         | 387     | 306                                                       | 426     |
| 3        | 358                                                         | 358     | 280                                                       | 392     |
| 4        | 362                                                         | 411     | 305                                                       | 434     |
| 5        | 296                                                         | 420     | 280                                                       | 424     |
| 6        | 246                                                         | 418     | 254                                                       | 416     |
| 7        | 352                                                         | 397     | 294                                                       | 421     |
| 8        | 290                                                         | 404     | 267                                                       | 411     |
| 9        | 243                                                         | 402     | 240                                                       | 402     |
| 10       | 326                                                         | 363     | 266                                                       | 387     |
| 11       | 272                                                         | 367     | 240                                                       | 381     |
| 12       | 232                                                         | 366     | 215                                                       | 374     |



Table 7.--Numbers of recruits, veteran females, remigrants and total nesting females for three steady state scenarios. Based on data of G. Balazs.

| Characteristics                   | Scenario |     |     |
|-----------------------------------|----------|-----|-----|
|                                   | 1        | 2   | 3   |
| •Neophytes recruited per year     | 30       | 43  | 72  |
| •Total mature female population   | 397      | 358 | 358 |
| •Number of veteran females        | 367      | 344 | 286 |
| •Average remigration fraction (%) | 31       | 29  | 25  |
| •Number of remigrants             | 114      | 101 | 72  |
| •Total nesting population         | 144      | 144 | 144 |





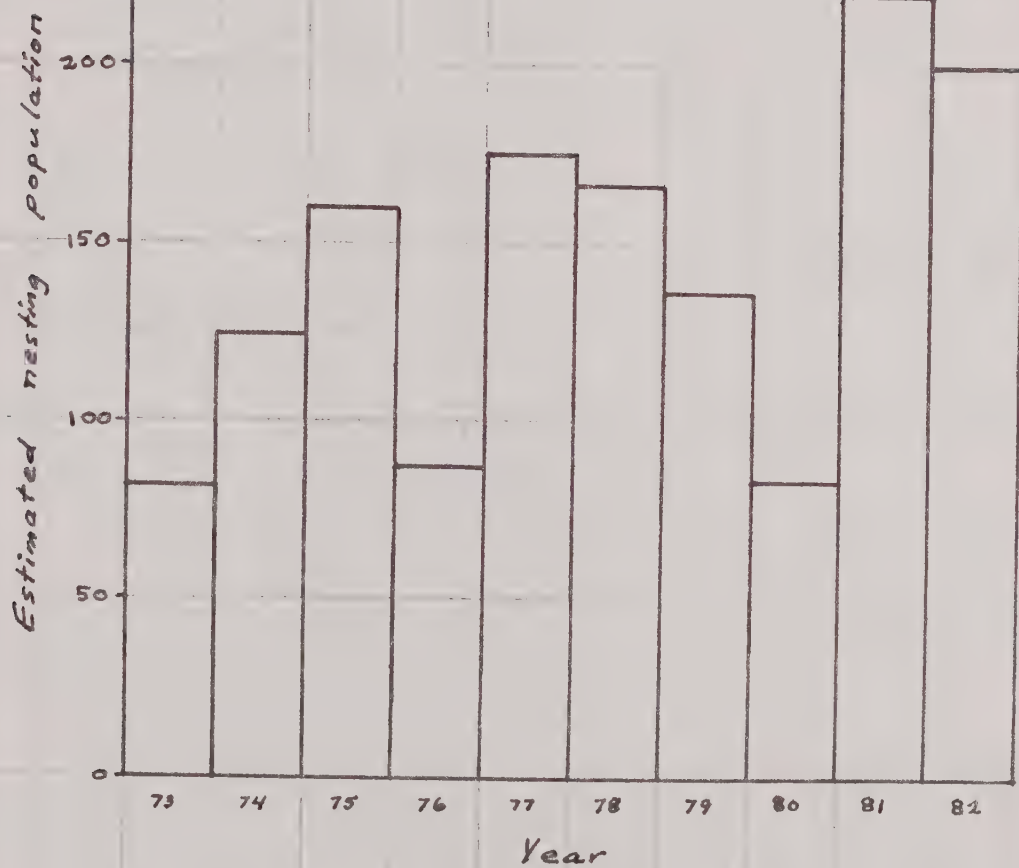


Figure 1.--Estimated nesting population at East Island, 1973-82.  
Based on data of G. Balazs.



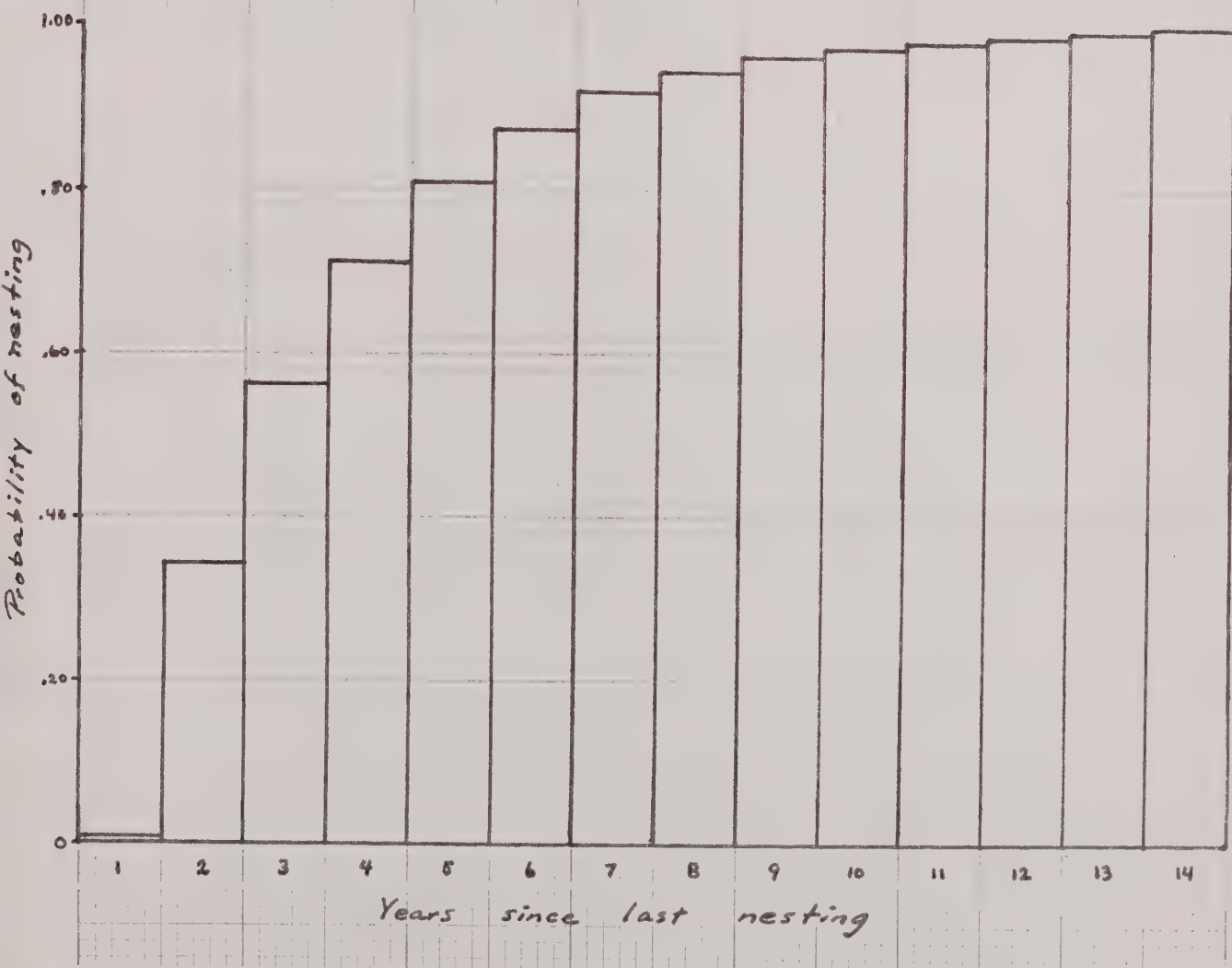


Figure 2.--Probability of hauling out and nesting as a function of years elapsed since last nesting, for females at East Island.  
( $\alpha = 0.42$ ,  $\theta = 0.99$ )



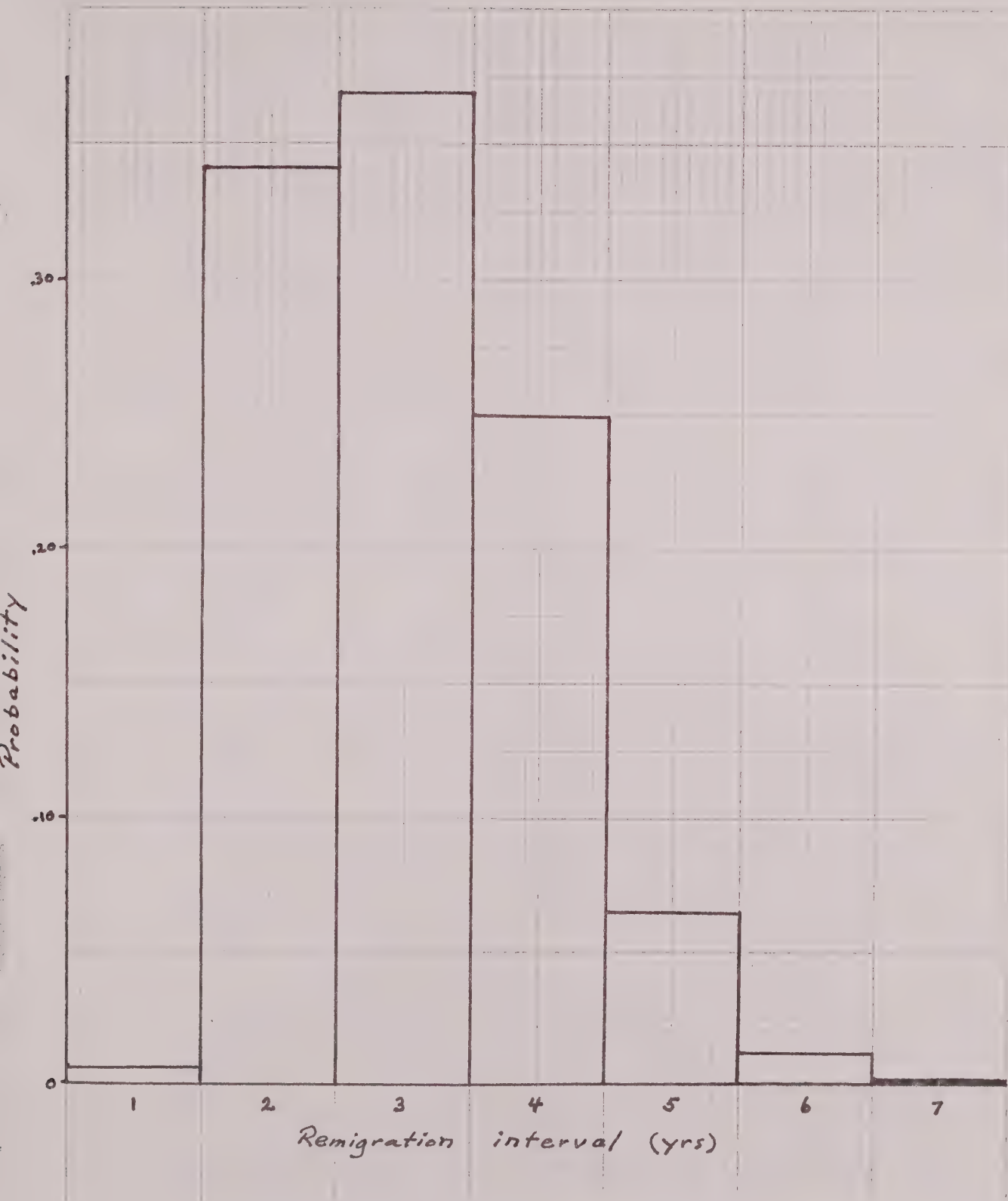


Figure 3.--Probability distribution of the remigration interval (years between successive nestings) for females at East Island.  
( $\alpha = 0.42$ ,  $\theta = 0.99$ )











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A SUMMARY OF THE 1983 TUNA BAITFISH WORKSHOP

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F/SWC2

Dear Participant:

The draft tuna baitfish workshop report mailed to you earlier has been revised according to comments and suggestions received from several participants. Enclosed is the final report.

Once again, may we take this opportunity to thank you for participating and making the workshop a success.

Sincerely,

Richard S. Shomura  
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Enclosure



An informal tuna baitfish workshop, cosponsored by the Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service (NMFS) and the Hawaii Division of Aquatic Resources (DAR), was held at the NMFS Kewalo Research Facility on April 14, 1983. Eight informal papers presented at the workshop addressed past and present trends and the status of the baitfish fishery, substitute bait, habitat enhancement, and economic considerations. The 71 persons attending the workshop included leaders of the tuna industry, boat owners, boat captains, interested fishermen, and scientists from NMFS, DAR, Naval Ocean Systems Center (NOSC), and the University of Hawaii's Institute of Marine Biology (HIMB).

The purposes of the workshop were to review the problem of bait shortage in the Hawaiian skipjack tuna fishery and identify possible solutions. The workshop was organized into six sections, as noted below.

The informal nature of the workshop encouraged discussion and a free exchange of ideas among the participants, who all had a common interest (1) in finding short-term solutions to the current critical bait shortages, particularly in time for the 1983 summer fishing season, and (2) to identify long-term goals and objectives to assure sustained bait production for the future well-being of the aku fishery.

#### 1. Present status of the aku fishery

From a review of the status of the aku fishery, it was apparent that aku production declined sharply in mid-1982. The 1982 total catch was only 6,600 lb above that of 1980, the poorest year on record.

The very low catches for 1980-81 prompted appeals from the industry for assistance and relief from the problems of bait shortage and mortality that almost constantly plague the fishermen. Discussed were research projects such as nehu habitat enhancement that could provide quick relief.

The review also brought out that aku production steadily declined from 9.2 million lb in 1971 to 2.4 million lb in 1980. Catch/boat showed a similar downward trend. It was noted that during this period of declining catches, Federal, State, and academic researchers had not taken an active part in trying to solve some of the problems, particularly as they relate to bait mortality and shortages. Criticisms and past feelings aside, it was brought out that the industry and the scientific community must come together to seek possible short-term and long-term solutions to keep the industry viable.

Discussion then focused on the current Aku Catch Report form, which even when filled out properly according to instructions, left much to be desired. Modification of the presently used form was strongly recommended.

The occurrence of "red mud" (red tide) in Pearl Harbor has also been a long-time concern of the fishermen. DAR identified this phenomenon as a dinoflagellate bloom. Apparently, water from "red mud" areas pumped into aku boat baitwells has caused total mortality of nehu. A baitwell aeration device, developed through the cooperative efforts of boat captains and DAR biologists, has apparently proved helpful.

It was pointed out that catching bait in Pearl Harbor's West Loch is no longer practical because almost no bait is available in this sector. The question asked was whether this condition is merely temporary or more or less permanent.

On other species, it was questioned whether substitute cultured bait could be made available in time for the upcoming aku season and whether the species being considered for culture would be acceptable to the fishermen.

Other questions raised during the review addressed the problem of whether nehu habitat could be enhanced, and whether significant declines in nehu abundance could be reversed.

All the boat captains agreed that nehu aggregated near recently dredged areas. Preliminary tests conducted in the past indicated that bottom sediment agitation or disturbance served as a concentrating mechanism for nehu. Some workshop participants felt the concept had merit and strongly supported it as a means of providing quick relief for the aku boats. Furthermore, it was highly recommended that research should continue in finding a viable substitute bait and that research be initiated in enhancing nehu habitat.

## 2. Review of the nehu fishery

Discussion centered on statewide historical catches, baiting effort, and catch per effort of baitfish in 1960-81. It was noted that significant changes had occurred in bait catching practices over the 22-year period examined. The 10-year period from 1960-69 was one of rather low catches and fishing pressure compared with the 10-year period from 1970-79. Whereas the total catch in 1960-69 averaged 32,300 buckets, the 1970-79 catches averaged 21% higher or roughly 39,200 buckets. In 1980-81, the average annual catch declined to only 26,500 buckets.

The review also brought out that the practice of catching bait at night has declined steadily since 1965, and in recent years practically none of the vessels were engaged in this type of activity. As a consequence, day-bait catching effort has increased significantly.

Over the years examined, Pearl Harbor and Kaneohe Bay were, by far, the most important bait grounds, contributing 33% and 37%, respectively, to the statewide bait catches. The remaining catches were contributed by a number of other areas of minor importance such as Ala Wai Canal, Haleiwa, and the neighbor island sites.

Pearl Harbor showed rather wide fluctuations in bait catch and effort over the years 1960-81 but catch/effort has remained relatively constant with no noticeable trends. However, rather dramatic changes have occurred over the years in Kaneohe Bay. Total bait catch and effort rose significantly in 1966 and again in 1973. Also, whereas effort increased 96% from 1972 to 1977 in Kaneohe Bay, catch rose only 60% during the same period. After 1973, when catch/effort peaked in Kaneohe Bay, the index of relative abundance declined steadily. It was determined that the fishery is probably not the cause of the decline but that a decline in food supply may be responsible.



The review also dealt with nehu mortality, pointing out that before 1967, baitfish mortality fluctuated between 12% and 21%. In 1967-81, the mortality fluctuated between 20% and 30%. Mortality is usually lower during the summer and the reasons cited were that bait is used faster in summer and that summer bait may be stronger.

Nehu spawn all year long and spawning peaks in summer although this peak may shift to late winter and early spring. Nehu eggs are planktonic, and incubation is about 24 hours. Growth of larvae after hatching is rapid and metamorphosis to the adult stage occurs in 6-7 weeks. From time of hatching, 8 to 12 weeks are required before nehu are sexually mature at approximately 30 mm standard length. Very few nehu live longer than one year.

It was pointed out that there has been a gradual increase in the catch of "sardine" which reached 10% in 1977 and nearly 21% by 1981. The species is actually a herring common to waters of the Marshall Islands and not the Marquesan sardine that was originally introduced from the Marquesas Islands in the late 1950s.

The ensuing discussion indicated that the fishermen strongly believe that introductions of talapia and sardine were responsible for the decline in the nehu population. Some fishermen stated that these species fed extensively on larval, juvenile, and adult nehu. Pollution of the habitat resulting from discharge of wash water from fertilizer barges was also cited as a cause for decline in nehu abundance.

### 3. Review of alternative species

a. Mollies (Maui Project).--The Maui mollie culture facility at Kealia started production in 1978 to determine the feasibility of culturing a supplemental baitfish. Based on past results of HIMB experiments and sea tests conducted in American Samoa, the project concentrated on the Mexican topminnow, which exhibited most of the characteristics of a good baitfish. The facility uses brood ponds, fry collecting troughs, and rearing ponds. It was reported that mollies could be reared to bait size in three months. To enhance production, solar domes to raise temperatures and a waste recycling system was instituted, the latter based on the concept of fertilizing water with duck manure. The ponds were also stocked with silver and grass carps and mullet.

Comparison of aku catch rates using mollies and nehu demonstrated that differences were relatively small, particularly when fishing schools around fish aggregating devices. For open-sea school fishing, the aku boat ORION caught 15.28 lb of aku/lb of mollies. It was pointed out that fishing methods, particularly chumming to hold the school near the stern, have to be modified when fishing with mollies.

It was brought out that about 2,000 lb of mollies were being reared for delivery to an albacore boat for testing this summer in the Hawaiian Islands. Near-term goals were to culture as much as 3,000-4,000 lb for aku fishing and that plans are underway for construction of a large-scale facility.

b. Culture experiments in the South Pacific.--Mollies and milkfish have been the species of primary interest of some South Pacific island governments in the culture and use of bait in tuna fishing. Results from trials conducted in American Samoa, Palau, Tonga, French Polynesia, Kiribati, Cook Island, and Pitcairn Island were reviewed. At several locations, trials with mollies and talapia were discontinued due to lack of interest and lack of funds. Among the more encouraging results were those the South Pacific Commission (SPC) in French Polynesia where the HATSUTORI MARU, a vessel chartered for aku tagging, obtained a catch rate of 34.7 lb/unit of bait (UOB) using milkfish as bait. At Kiribati, the following aku catches were obtained: 38.5 lb/UOB with mollie and 55.9 lb/UOB with milkfish. In comparison, for the period 1950-72 nehu yielded a catch of 16-37 lb/UOB in Hawaii. Thus, on this basis, nehu could be termed a poor baitfish by the SPC researchers. It was also reported that many of these trials were based on small amounts of bait; however, it appears to be rather clear that milkfish is a much better baitfish than mollies.

c. Tilapia and threadfin shad.--A pilot tilapia culture plant, established in Paia, Maui, produced roughly 450 buckets of baitfish in each of the two years that the plant was in operation (1958-59).

Test fishing with bait produced at this plant yielded an average of 53 lb of aku/lb of tilapia as compared with 64 lb of aku/lb of nehu. Fishing was conducted using each bait species alternately on schools encountered. For wild schools and schools of large aku, tilapia proved to be relatively effective.

Results from this pilot study led eventually to the establishment of the State's tilapia culture station at Sand Island in 1960. This facility produces about 3,000 lb of baitsize tilapia per year; maximum production was 5,000 lb per year.

Field trials with threadfin shad on the R/V CHARLES H. GILBERT produced good results. Shad, a freshwater species found mainly in Wahiawa Reservoir on Oahu, is not easily obtained, and the capture, transport, and acclimation procedure could be expensive as well as labor-intensive. It has been estimated that from 5,000 to 10,000 buckets of shad inhabit the reservoir and that shad abundance is probably related to water level in the reservoir.

d. Mullet and milkfish culture.--Research on mullet at Oceanic Institute began in 1969 but it wasn't until 1980-82 that mass production research, funded by Pacific Tuna Development Foundation (PTDF) and the State, got underway. Mullet attain sexual maturity in three years and experimental results indicate that an average fertilization rate of 90% and an average hatching rate of 70% are expected. About 600,000 viable eggs can be obtained from an adult female.

The hatched larvae are fed cultured rotifers, which in turn were fed cultured phytoplankton. Larval survival ranged from zero to 50%. About 45 days are required for the larvae to reach the fry stage.

Current plans call for shifting from tank to pond culture which should cut down the production cost.

Research on milkfish is still ongoing at Oceanic Institute.



#### 4. Habitat enhancement

From a review presented earlier and based on discussions that ensued, it was apparent that immediate relief was necessary to help the industry. Discussion led to agreement among the boat captains that habitat enhancement looked like an attractive near-term solution and that a project to stir up the bottom sediment at selected localities should be strongly recommended. Because of possible environmental and legal constraints in pursuing such a project, it was recommended that the US Corps of Engineers be consulted or invited to attend the Hawaii Fishery Coordinating Council (HFCC) meeting where short- and long-term solutions to the bait problem were to be recommended and discussed.

The Workshop was opened to comments from two investigators who reported on (1) water quality studies conducted at Pearl Harbor and on (2) nehu population studies in Kaneohe Bay. Sediment metabolism studies currently underway at three primary locales in Pearl Harbor will examine the effect of sewage diversion on the total ecosystem. It was indicated that although sewage diversion will reduce nitrogen and phosphorus in the ecosystem, the nutrients available to phytoplankton will not be cut off overnight or completely. Much nitrogen and phosphorus will still enter Pearl Harbor through streams that empty into the harbor. Nutrients are also expected to leach at high rates from accumulated bottom muds for at least several months.

It was noted that red tide blooms have increased significantly since Hurricane IWA, possibly in response to "Kona" winds which decrease circulation in the harbor and cause nutrient concentrations to increase.

Presently the US Navy conducts only routine environmental monitoring required by the Environmental Protection Agency (EPA). There is no intensive monitoring of overall environmental conditions going on at this time.

Pearl Harbor was described as heavily stressed and no living corals can be found in the harbor probably because of the high concentrations of heavy metals. Nehu, however, show no apparent direct effect from heavy metal pollution. It is likely, however, that heavy metals and other pollutants may affect planktonic organisms constituting the nehu's diet.

A study of the nehu population in Kaneohe Bay has produced results which indicated that the adults and large larvae migrate into shallow water to seek shelter along the coast during the day and move into deep waters of the bay at night. Eggs and newly hatched larvae are found primarily in deep water.

#### 5. Economic considerations

In discussing economic considerations, it was noted that demand and price were the two most important considerations. The topminnow was cited as an example of a good cultured bait that can be produced rather cheaply. Based on 1980 data, it was estimated that initial start-up costs could reach \$23,000/acre of pond and annual operating costs would be about \$16,000/acre. The cost of producing topminnow was estimated to be about \$1.60/lb (10,000 lb/acre production) and \$2.70 lb (6,000 lb/acre production). The current cost of production is estimated at about \$3.00/lb with production of 8,500 lb/acre. The question is whether there is a demand for topminnow at this price.

It was added that in 1980, Japanese pole-and-line fishing boats paid \$1.70-1.80/lb for natural bait. Based on the ratio of tuna price and cost of bait, it was estimated that if topminnow cost \$3.00/lb, then the price of tuna should be \$1.04/lb or \$2,310/ton.

## 6. Recommendations

The participants developed recommendations for presentation to the HFCC. These recommendations were categorized into those that needed immediate attention or short-term solutions and those requiring more detailed long-term research.

Among the short-term recommendations were:

1. Enhance the natural habitat of nehu by stirring up or agitating bottom sediment. It was noted that this project, which was considered top priority, would provide quick relief by attracting nehu from surrounding areas; however, there is danger that this action may further reduce the already low abundance of the existing nehu stock.

2. Seek access to grounds where nehu are known to congregate but which are off-limits due to private or government-imposed restrictions.

3. Identify all facilities that could be put into immediate operation for culturing either tilapia or mollies. The consensus among the boat captains, however, was that mollies were preferred over tilapia.

4. Examine impact of and possibly remove restrictions, if any, on sale of tilapia and "sardine" so that the boats may be able to sell these species when they are captured in the bait seines.

5. Modify the presently existing Aku Catch Report form so that more meaningful catch and effort statistics could be collected not only for scientific analysis but also so that more feedback can be provided to industry.

Long-term recommendations included:

1. Compile and analyze available information and conduct a full investigation on the ecosystem in Pearl Harbor and Kaneohe Bay to determine how natural phenomena and man-induced activities influence or affect the nehu populations.

2. Encourage continued research on milkfish culture so that the species could be eventually produced on a large scale as baitfish.

## APPENDIX 1

## AGENDA

Opening statement (Richard Shomura/Henry Sakuda)

Objectives of workshop

1. Present status of the aku fishery (John Robey)
2. Review of the nehu fishery (Richard Uchida)
3. Review of alternative species
  - a. Mollies (Maui project) (Fred Matsumoto)
  - b. Culture experiments in the South Pacific (Wayne Baldwin)
  - c. Tilapia and threadfin shad (Thomas Hida)
  - d. Mullet and milkfish culture (Cheng Sheng Lee)
4. Habitat enhancement (Henry Okamoto)
5. Economic considerations (Yung C. Shang)
6. Recommendations (open discussion)

Short-term

Long-term

## APPENDIX 2

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